

E L E M E N T S
O F T H E
A R T O F D Y E I N G.

By M. BERTHOLLET,

Doctor of Medicine of the Faculties of PARIS and TURIN,
Member of the Academy of Sciences at PARIS, of the
Royal Society at LONDON, and of the Philosophical
Societies of TURIN, HARLEM, and MANCHESTER.

TRANSLATED FROM THE FRENCH

By WILLIAM HAMILTON, M. D.

Physician to the London-Hospital, and Lecturer of Chemistry.

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No 75.



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PART THE SECOND
O F T H E P R O C E S S E S O F A R T.

S E C T I O N I.

Of Black.

C H A P T E R I.

Of the Processes for dyeing Black.

WE know but very few substances capable of affording by themselves a permanent black, and these have been tried only on linen and cotton. The juice of the cashew-nut, or *anacardium* of India, communicates a black colour, that will not wash out, and even

resists boiling with soap or alkalis. It is used for marking linen. The *anacardium occidentale* affords likewise a durable dye, but it is merely of a brownish colour.

The juice of the *toxicodendron* produces nearly the same effect. That of the stalks of the hop-plant gives a very durable brownish red colour. The juice of the flœ affords a pale tint of a brownish hue, which becomes deeper after having been repeatedly washed with soap, and afterwards wetted with a solution of alkali. On boiling flœs, their juice becomes red, and the red tinge, which in that state it imparts to linen, is converted by washing with soap into a bluish colour of some durability^a.

According to Linnæus^b, the juice of the berries of the *acæa spicata* or *cristophoriana* affords a black ink with alum; and that of the berries of the *impetrum procumbens*, or *erica baccifera nigra*, a black colour inclining to purple when alum is mixed with it.

In the Brasils there grows a tree called by botanists *pomifera indica tinctoria*, or *genipa americana*, the berries and leaves of which afford a blue black that resists the action of soap.

^a Lewis's Philosophical Commerce of Arts. vol. ii.

^b Amœnitates academicæ.

• The methods of obtaining a black colour which I have just recounted, cannot be employed in dyeing, because the substances from which it is procured are not to be gathered in sufficient quantity to supply the demands of the art, and the black which they afford is by no means comparable to that formed in the common processes of the dye-house. All black colours, therefore, are the effects of combination. To produce them, the black particles formed by the union of the astringent principle with the oxyd of iron held in solution by an acid, are fixed on the stuff.

What I have already said on the astringent property, and the manner in which astringents act on the oxyd of iron, and combine with it, to form black particles, in the fifth chapter of the first section of the former volume may be referred to: but it is to be observed, that when the particles are precipitated from the mixture of an astringent and a solution of iron, they have only a blue colour; if they be then left exposed to the air, and moistened with water, their colour grows deeper, but still the blue is distinguishable in it. The stuff itself then contributes to increase the intensity of the black, whether it be, that in this state of combination, it undergoes a slight combustion, or

that the colouring particles undergo a further degree of combustion from presenting a larger surface to the air: for without the action of the air a fine black cannot be obtained, on which account, the operations about to be described are performed at different intervals, during which the stuff is taken out of the bath, that it may be exposed to the air. I have ascertained, that black stuffs placed in contact with pure air diminish its volume, and of course absorb a certain quantity of it.

According to the process described by Helot*, woollen cloth to be dyed black, ought to have received the deepest blue tint, or mazarin blue, to have been washed in the river as soon as taken out of the vat, and afterwards cleaned at the fulling-mill.

For a hundred pounds of stuff, ten pounds of logwood, and ten pounds of aleppo galls powdered, are put into a bag, and boiled for twelve hours in a middle sized copper, with a sufficient quantity of water. One third of this bath is put into another copper with two pounds of verdgris, and into this the stuff is put, stirring it continually for two hours, observing to keep the bath very hot without

* L'art de la Teinture en Laine, &c.

letting it boil. The stuff is then taken out, and a portion of the bath equal to the former, is put into the copper with eight pounds of vitriol or sulphat of iron. The fire is now to be diminished, and the bath suffered to cool for half an hour, whilst the vitriol dissolves; when the stuff is again put in, moved about well for an hour, and then taken out to air. Lastly, the remainder of the bath is added, taking care, that the bag be well pressed out. Fifteen or twenty pounds of sumach are now put in, and the bath is made to give one boil, which is immediately stopped with a little cold water: two pounds more of sulphat of iron are added, and the stuff is kept another hour. The stuff is now washed, aired, and again put into the copper, constantly stirring it for an hour: it is then carried to the river, well washed, and fulled. When the water comes off clear, another bath is prepared with weld, which is made to boil for a moment, and after being cooled, the stuff is passed through it, to soften it, and render the black more firm. In this manner a very beautiful black is obtained, without making the stuff too harsh.

In general more simple processes are employed. Thus blue cloth is merely boiled in a bath of galls for two hours; it is then kept

two hours in the bath of logwood and sulphat of iron, without boiling ; and afterwards washed and fulled.

Mr. Hellot has found the following method answer. For fifteen ells of deep blue cloth, a bath is to be made with a pound and half of yellow wood, five pounds of logwood, and ten pounds of sumach. After having boiled the cloth in this for three hours, it is taken out, ten pounds of sulphat of iron are put into the copper, and the cloth is kept in it two hours longer : it is then aired, put into the bath again for another hour, and afterwards washed and fulled. This black is less velvety than that of the process first described. The same gentleman has found by experience, that the madder prescribed by the ancient regulation tends only to give a reddish cast to the black, which is much more beautiful and velvety without madder.

Black may be dyed without a blue ground, and this is done for stuffs of low price. In this case a *root colour ground* is first given them, that is, they are dyed fawn colour with green walnut-peels, or the root of the walnut-tree ; they are then blackened as directed above, or in some other manner ; for it is obvious, that black may be obtained by various processes.

Logwood

• Logwood increases the beauty of the black dye; but the quantity of galls may be diminished by increasing that of the sumach, which indeed may be used altogether instead of them, as is done in some eminent manufactories.

The proportions most generally adopted by the english dyers are, according to Lewis, for a hundred pounds of woollen cloth, dyed first a deep blue, about five pounds of sulphat of iron, five pounds of galls, and thirty of logwood. They begin with galling the cloth, and then pass it through the decoction of logwood, to which the sulphat of iron has been added.

When the cloth is completely dyed, it is washed in a river, and fulled till the water comes off clear and colourless. Some recommend fine cloths to be fulled with soap-suds: but this operation requires an experienced workman, to cleanse the cloth perfectly of the soap. Many advise, to give the cloth a dip in a bath of weld, when it comes from the fulling-mill, which they say softens it, and at the same time fixes the black. Lewis says, that the weld bath is totally useless when the cloth has been treated with soap-suds, though in other cases it may be of advantage: he does not, however, ascribe its effects to any quality

of the weld, but to the alkali with which the dyers commonly prepare its decoction. Yet the weld itself may act by dissolving the black particles which are not fixed in the cloth by its attraction for them.

It is said in the Stockholm Transactions for 1753, that *uva ursi*, gathered in autumn, and carefully dried so that the leaves may remain green, may be employed instead of galls. The method there directed is to boil a hundred pounds of wool, with sixteen of sulphat of iron and eight of tartar, for two hours. The next day the cloth is to be rinsed as after aluming. A hundred and fifty pounds of *uva ursi* are then to be boiled in water for two hours, and after being taken out, a little madder is to be added to the liquor, at the same time putting in the cloth, which is to remain there an hour and half, or an hour and three quarters, after which it is to be rinsed in water. Lewis observes, that this process gives a pretty good black to blue cloth, but to white only a deep brown, and that the madder and tartar are useless. The *uva ursi* precipitates the sulphat of iron in large black grains, which diffuse themselves through the water.

In dyeing silk black, different operations are to be distinguished: boiling the silk, galling it, the
the

the preparation of the bath, the operation of dyeing, and softening the black.

Silk, as has been observed in the preceding volume, contains naturally a substance called its gum, which gives it that stiffness and elasticity observed in its natural state. This substance does not increase the strength of the silk, which is then called raw; on the contrary, it renders it more liable to wear out from the stiffness it imparts to it: and though raw silk takes a black colour with more facility, than silk which has been scoured or divested of its gum, that black is much less perfect with respect to intensity, and resists the reactives calculated to dissolve the colouring matter much less powerfully.

To cleanse silk intended to be dyed black, it is commonly boiled four or five hours, with a fifth of its weight of white soap, after which it is beetled, and carefully washed.

For galling the silk, nearly three fourths of its weight of galls are boiled for three or four hours: but as aleppo galls are dear, a greater or less portion of white galls, or even of an inferior kind called berry or apple galls, is mixed with them. The proportion commonly used at Paris is two parts of aleppo galls to eight or ten of berry galls. After the boiling,

the liquor is left at rest about two hours, that the galls may subside: the silk is put into the bath, and left there from twelve to thirty-six hours: it is then taken out, and washed in the river.

Silk being capable of combining with more or less of the astringent principle, whence its weight receives a considerable augmentation, not from the weight of the astringent principle alone, but also from that of the colouring matter, which fixes in it in proportion to the quantity of the astringent principle combined with it, the processes for dyeing it are varied, according as the operator is desirous of rendering the silk more or less weighty. This requires some explanation.

Silks are sold in two different ways; by weight, and by measure. This formerly distinguished the silk trade of Lyons from that of Tours; silks being sold at the former place by measure, at the latter by weight. It was the interest, therefore, of the manufacturer of Tours to increase the weight, and of the manufacturer of Lyons to be sparing of his ingredients. Hence the distinction of light black and heavy black. At present both methods of dyeing are followed at Lyons, as silks are sold there in both ways.

A pound

A pound of filk loses nearly one fourth of its weight in the boiling (cuite) when complete; and it recovers in the light black, and the galling which precedes it, an ounce and half, or two ounces; so that the original pound is reduced to about fourteen ounces: but in the heavy black this same pound is increased in weight to twenty or twenty-two ounces, or even more, so that the buyer, deceived by the low price at which it is offered him, pays in every pound for several ounces of a substance which is not merely useless, but is even injurious to the beauty of the colour and the strength of the stuff. The dyers of Tours, who deal with that honesty which renders trade honourable, and is the chief support of credit, raise the original pound to fifteen or sixteen ounces only. The black which is greatly over-charged, is styled english black, as it is pretended to have come from England. As the black which is much over-charged is never of a fine colour, it is generally employed for the woof, and covered with a warp of a fine black.

The difference of the process for obtaining heavy black consists in leaving the filk a longer time in the gall-liquor, in repeating the galling, and dipping the filk in the dye a greater number of times, leaving it in this also a considerable

able while. The first galling is commonly performed with galls which had been already used, fresh ones being taken for the second. But this method would be insufficient to give so great a surcharge as we find in the english black. For this, the silk is galled raw, and afterwards rendered supple by wringing with the pin.

Silk-dyers preserve a vat for the black, and its composition, greatly overcharged, varies in different dye-houses. These vats have commonly been set for many years, and when the black dye is exhausted, it is renewed by what is called a brevet. When the grounds which accumulate in them become too considerable in quantity they are taken out, so that after a time nothing remains of several of the ingredients which composed the original bath, but which are not used in the brevet. The description of a bath and brevet of this kind may be seen in Macquer ^d. In this process there are seeds of fenugreek, fleawort, cummin, colocynth, buckthorn berries, agaric, nitre, ammoniacal muriat, sal gem, litharge, antimony, lead ore, orpiment, corrosive muriat of mercury, &c. Macquer confesses, that many of

^d Art de la Teinture en Soie.

these ingredients are useless ; in fact, several of them are no longer employed : but the compositions of every country, and indeed of every dye-house, differ.

Iron filings are generally added to the dye bath ; but some dyers, particularly at Tours, use in its stead the powder found in the troughs of cutlers grindstones *. The action of this powder depends probably on the particles of iron it contains, which are in a state of extreme division.

Whilst the silk is preparing for dyeing the bath is heated, taking care to stir it occasionally, that the grounds which fall to the bottom may not acquire too much heat. This bath ought never to be heated so far as to boil. Gum and solution of iron are added in greater or less proportions, according to the different processes, and when it is judged that the gum is dissolved, and the bath is near boiling, it is left to settle for about an hour. The silk is then dipped into it, being, in general, first divided into three parts, each of which is put into the bath successively. Each part is wrung gently three times, and hung up to air after

* This is known among our workmen by the name of *S'ippe*. T.

each wringing. The purpose of this operation is to squeeze out the liquor with which the silk is impregnated, and which is exhausted, that it may imbibe fresh, and more especially to expose the silk to the action of the air, which renders the black deeper.

After each portion of the silk has had three wringings, it is necessary to heat the bath anew, putting in gum and sulphat of iron as the first time ; and the operation performed in the interval between two heatings, is called a *fire* (un feu). The light black has only two fires ; but the heavy requires three, and for this the silk is suffered to remain in the bath about twelve hours after the last fire. Sixty pounds of silk, termed a copper, are commonly dyed at one operation. If only half that quantity be dyed, one fire is sufficient for the light black.

When the operation of dyeing is finished, some cold water is put into a back, and in this the silk is rinsed (disbrodé) by turning or flaking over.

Silk, when taken out of the black dye is extremely harsh. The operation by which it is deprived of this quality is styled *softening*. For this purpose a solution of four or five pounds of soap to every hundred pounds of silk,

filk, is poured through a cloth into a large vessel of water: being well mixed, the filk is put in and left about a quarter of an hour, after which it is wrung out and dried.

To dye raw filk, it is galled cold in the gall bath which has already been used for scouring filk. Silk with the natural yellow hue is preferred for this purpose. It must be remarked, that if you would preserve a part of the gum of the filk, and afterwards soften it, the galling should be performed in a warm bath as usual: but here, where it is intended to preserve the whole of the gum, and the elasticity which it communicates to the filk, the galling is performed cold. If the gall liquor be weak, the filk is left in it for several days.

The filk thus prepared and washed, readily takes the black dye, and the rinsings, to which sulphat of iron may be added, suffices to communicate it. This dyeing is performed cold; but it requires more or less time according to the strength of the rinsings. Sometimes three or four days are necessary; after which it is washed, giving it one or two beetlings, and is dried without wringing, that it may not be softened.

Raw filk may be dyed more speedily by turning or shaking it over in the cold bath after galling,
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and airing it, repeating these operations a few times ; after which it is to be washed and dried as above.

Macquer describes a more simple process for the black, with which they dye velvet at Genoa, and he says, that this process rendered even still more simple has succeeded completely at Tours. It is as follows.

For a hundred pounds of silk, twenty pounds of aleppo galls in powder are to be boiled an hour in a sufficient quantity of water. The bath is then left to settle till all the galls have fallen to the bottom, when they are taken out, and two pounds and a half of english vitriol, twelve pounds of iron filings, and twenty pounds of gum collected from the trees of the country, are put into a copper cullender with two handles, and immersed in the bath. The cullender is supported by sticks, so as not to touch the bottom, and an hour is allowed for dissolving the gum, which is occasionally stirred. If at the end of the hour any gum remain in the cullender, it is a proof, that the bath which contains two hogsheds (deux muids) has acquired as much as is necessary : if, on the contrary, all the gum be dissolved, three or four pounds more may be added. The cullender is still left in the copper, taking it
out

out only whilst dyeing, and putting it in again, as soon as that operation is over. The copper must be kept hot the whole time, but without boiling. The silk is galled with one third of aleppo galls, leaving it in the liquor six hours the first time, and twelve hours the second. The rest of the process is conducted in the common way.

Lewis says, that he has tried this process in the small way, and by adding more and more sulphat of iron, and repeating the immersions of the silk a great number of times, he has at length obtained a fine black.

In fact, the sulphat of iron appears to be in too small proportion in the process described by Macquer, and inconveniences were no doubt found to attend it, as it is no longer followed at Tours. Lewis thinks that the gum is useless, and that it is all carried off in washing the silk: but it is probable, that if he had continued to dye in the same bath, he would have found it contribute to keep it up. The quantity above directed appears, however, to be excessive. If the quantity of gum be lessened, it would be particularly useful to add the sulphat of iron in separate portions after each fire.

Lewis remarks also, that though white silk may be dyed a good black, without using either logwood or verdgris, the addition of those two ingredients contributes greatly to improve the colour in silk as well as in wool.

The quantity of galls used in dyeing silk black renders it very expensive, as their price has been considerably raised. It is of consequence therefore, to find some method of lessening their quantity. The following process is taken from a memoir of Mr. Anglès, who was a competitor for the prize proposed in 1776 by the academy of Lyons, of which this was the object.

Silk carefully boiled (*cuite*) and washed in the river, is to be immersed in a strong decoction of green walnut peels, and left in it till the colour of the bath is exhausted. It is then taken out, slightly rung with the pin, dried, and washed in the river. The decoction of walnut peels is made by boiling a full quarter of an hour, when it is taken from the fire, and suffered to subside before dipping the silk, which has been previously immersed in warm water. A blue ground is next given by means of logwood and verdgris. For every pound of silk, an ounce of verdgris is dissolved in cold water, the silk is left in this solution two hours,

hours, it is then dipped in a strong decoction of logwood, wrung out slightly, and dried before it is washed at the river. For light blacks, galling may be altogether omitted; but to obtain a heavy black, half a pound of galls must be used for every pound of silk.

To prepare the bath, two pounds of galls and three of sumach are macerated in twenty-five gallons of water over a slow fire, for twelve hours. After straining, three pounds of sulphat of iron and as much gum arabic are dissolved in it. In this solution the silk is dipped at two different times, leaving it in two hours each time, taking care to air it after the first dipping, and to dry it before giving the second fire, when it is to be again aired and dried: it is then beetled twice at the river; after which a third fire is given it, in the same manner as before, except that it is left in the bath four or five hours. When drained and dried, it is again beetled twice at the river. Care must be taken, that the heat, during the operation do not exceed the mean term between freezing and boiling water, or forty degrees of Réaumur's thermometer (122 degrees Fahrenheit); and before the last two
C 2 fires,

fires, half a pound of sulphat of iron and as much gum arabic must be added.

For removing the harshness silk acquires from the black dye, Mr. Anglès prefers the decoction of weld to the solution of soap.

Mr. Anglès says, that if silk be dyed blue with indigo previous to its being dipped for black, it will take only a mealy black, but that a velvety black will be obtained if it be prepared with logwood and verdegris. He says also, that green walnut peels soften the silk. Though a fine black may be procured from green walnut peels, and the bath above described, he notwithstanding adds logwood and verdegris, that he may not be obliged to use a large quantity of sulphat of iron, which weakens the silk too much. Lastly, he thinks, that galls serve only to give the silk weight, and that sumach is sufficient for the dye.

Linen and cotton do not easily take a black of any intensity that will resist soap, so that to dye them black, particular processes are necessary, and hitherto few dyes have been found to give satisfaction.

For dyeing cotton and linen black, a solution of iron is used which is kept in a cask, called the *black cask*. This solution is prepared with vinegar or small beer, or small wine
made

made from the grapes after they have been pressed by adding water to them, which is soured with rye meal, or some other ingredient, in order to procure an acid liquid at a low price. Pieces of old iron are thrown into this liquor, which is left to stand till wanted, but never used in less than six weeks or two months. To this bath astringents are frequently added, particularly the decoction of alder bark, which of itself has the property of dissolving a considerable portion of oxyd of iron.

Mr. le Pileur d'Apligny describes ^f the method followed at Rouen, for dyeing linen and cotton threads. They are first dyed sky blue in the vat, then wrung out and dried. They are next galled, using four ounces of galls to every pound of thread, and leaving them twenty-four hours in the gall liquor, after which they are wrung out and dried again.

About five quarts of the liquor of the black cask for every pound, are then poured into a tub, in which the thread is worked with the hand pound by pound about a quarter of an hour, when it is wrung out and aired. This operation is repeated twice, adding each time a fresh quantity of the black bath, which ought

^f L'Art de la Teinture des Fils & Etoffes de Coton.

to be carefully scummed. After this it is again aired, wrung out, washed at the river to cleanse it well, and dried.

When this thread is to be dyed, a pound of alder bark for every pound of thread is boiled for an hour in a sufficient quantity of water. About half the bath that served for the galling, and half as much sumach as alder bark are then added, and the whole boiled together for two hours, and then strained through a sieve. When the liquor is cold the thread is put into it on the sticks, and worked pound by pound, airing it from time to time : it is then let down into the bath again, left in it twenty-four hours, wrung out, and dried.

To soften this thread when it is dry, it is customary to soak and work it in the remains of a weld bath that has been used for other colours, adding to it a little logwood. From this it is taken out and wrung, and instantly put into a tub of warm water, into which has been poured an ounce of olive oil for every pound of thread. Lastly, it is wrung out and dried.

For printing cottons black, a solution of iron in acetous acid is used, and the stuff is dipped in the madder bath. Mr. le Pileur d'Apligny describes a process in which he employs madder

der also, for giving linen and cotton thread a black colour, which he speaks of as very fine and durable.

The thread is first to be scoured as usual, galled, then alumed, and afterwards dipped in the weld bath. When taken out of this bath, it is to be dyed in a decoction of logwood, to which a quarter of a pound of sulphat of copper has been added for every pound of thread. After this, it is to be washed in the river, and wrung several times, but not too hard. Finally, it is dyed in a madder bath, in the proportion of half a pound to each pound of thread. That the black may not be liable to be discharged, the thread must be dipped in a bath of soap-suds.

The method followed at Manchester is thus described by Mr. Wilson ^s. A galling is made with galls or sumach, after which the stuff is dyed with the liquor of the bath, consisting of a solution of iron in vegetable acid, frequently composed of alder bark and iron, and then dipped in a decoction of logwood with a little verdegris. This process is repeated till a deep black is obtained. It is necessary to wash and dry after each operation.

^s An essay on light and colours, and what the colouring matters are, that dye cotton and linen.

Mr. Gühliche describes a solution of iron, on which he bestows great encomiums ^h. He directs a pound of rice to be boiled in twelve or fifteen quarts (*mesures*) of water, till it is wholly dissolved; into this solution is to be thrown as much old iron made red hot, as will come half way up to the surface of the liquor. This is to be done in a vat exposed under cover to the air and light at least a week. An equal quantity of red hot iron is thrown into as much warm vinegar as there was solution of rice, in another vessel, and in like manner exposed to the air and light. After some days the contents of the two vessels are to be mixed together, and this mixture is to be left a week exposed to the open air. The liquor is then to be decanted, and kept in a close vessel for use.

The author says, that for dyeing linen and cotton, nothing more is necessary than to leave them in this liquor, till they have acquired a sufficient black, which will not require above twenty-four hours at most: that if the liquor do not contain enough of ferruginous particles, the stuff, after being taken out, must be put into a fresh portion of liquor: that, though

^h *Vollständiges Farbe und Bleichbuch, &c. band. ii.*

it appear only of a blackish gray, it produces the finest and most permanent black : and that it may be advantageously substituted instead of sulphat of iron for silk and wool, which only require to be dipped in a decoction of logwood when taken out of the bath, to give them a beautiful black.

The numerous experiments of Mr. Beunie have led to the results which I am about to lay before the reader, beginning with the preparations used by him in the two processes which he describes.

1. *Neutralized Alum.*

Dissolve ten pounds of powdered alum in fourteen gallons of well-water : dissolve also ten ounces of pot-ash in ten quarts of well-water : let the latter solution stand some time to settle, and when it is clear, pour it into the former, stirring it constantly.

2. *Liquor of Brasil-Wood.*

Boil twenty-five pounds of brasil-wood in fifty quarts of well-water for one hour : strain the decoction through a sieve, or linen cloth : put fifty quarts more of well-water to the residuum, and boil it again : strain this liquor, and put it into a cask with the former.

3. *Infusion*

3. *Infusion of Galls.*

Infuse four pounds of galls grossly powdered in fifty quarts of warm water. More galls might be used, which would render the liquor better.

4. *Solution of Iron.*

Put into a cask fifty gallons of good vinegar, fifteen pounds of iron filings, twenty-five pounds of old iron, and three pounds of common salt: draw off the vinegar occasionally, and pour it into the cask again. This solution will be fit for use in a month, but the older it is, the better.

5. *Another Liquor of Galls.*

Boil a hundred pounds of oak saw-dust, or small chips of oak, not lixiviated, in a hundred gallons of well-water, for two hours: press out the liquor and boil in it ten pounds of galls, and twenty-five pounds of logwood: strain and keep for use. This bath is the better for keeping.

Process for fine Goods.

Give your stuff an indigo ground, as deep possible in the warm vat; then dip into
No.

No. 1, wringing it a little, that the alum may penetrate it, and dry it in the shade. After this, soak it two hours, and rinse it well. When it is half dry, boil it half an hour in No. 2, adding a quarter of an ounce of verdgris, rinse it, and wring it well. It will now be a deep purple. When it is dry, soak it an hour in No. 3, taking care not to let it boil: take it out, and in a few hours put it again into No. 3, and afterwards into No. 4. Dry it, and then rinse it till the water comes off clear.

Process for low-priced Goods.

Dip your thread or cotton in No. 1, as above; then boil it in No. 2, with some verdgris; dip it next in No. 5, and lastly in No. 4, observing the directions given above.

It is useful on many occasions to give linen a print capable of resisting the action of soap or ley, to serve as a mark. Of all the methods that have been tried, that used in England appears to be the most effectual. A solution of silver is diluted with distilled water: in this a little gum is dissolved: the end of the cloth on which the mark is to be impressed, is impregnated with a solution of isinglass, and on this the gummy solution of silver is applied. This mark soon grows black.

C H A P. II.

Observations on the Processes for Dyeing Black.

IT appears, from the preceding descriptions of the processes, that experience has taught, that they should vary according to the nature of the stuffs to be dyed. I shall now endeavour to ascertain the circumstances which must occasion a variation in the processes, by recurring to the theory laid down in the chapter on astringents, and some observations inserted in this section.

The dyeing of wool is the most easy; wool having a greater attraction for the black particles than silk or cotton: yet particular attention is necessary to obtain a deep black, which may be permanent, and possessed of the lustre peculiar to that colour.

All astringents are capable of striking a black on wool: but the black struck with oak bark is not so durable as that struck with galls, though it is equally deep, if a sufficient quantity of the bark be employed.

Astringents differ from one another chiefly by the permanency of the black they produce,
and

and the quantity of the astringent principle they contain. To produce an equal intensity of colour, the quantity used ought to be in proportion to the quantity of their astringent principle. Logwood will not of itself strike a deep and lasting black, but in conjunction with galls, or sumach, it adds lustre to the colour. Of all the astringents we know, sumach approaches nearest to galls, with regard to the quality of the black it gives; and it appears to be even equal to them in that respect, but it does not contain so large a proportion of the astringent principle.

The proper quantity of vitriol or sulphat of iron, seems to be that which answers to the quantity of the astringent principle, so that the whole of the iron be precipitated by the astringent, and the whole of the astringent taken up by its combination with the iron: but as it is impracticable to hit this point with precision, it is better, that the sulphat of iron should be predominant, because the astringent principle when it is superabundant, opposes the precipitation of the black colouring particles, and even possesses the property of dissolving them.

This property of the astringent principle is so active, that if a pattern of black cloth be
boiled,

boiled with galls, it will be reduced to a gray ; and it has been seen, in the chapter on astringents, that the first black particles formed on mixing a solution of sulphat of iron with an infusion of galls were redissolved by the latter. This serves to explain an observation of Lewis, that if cloth be repeatedly dipped in the colouring bath after it has taken a good black, instead of the colour being heightened, it will be weakened, and become brownish, and that too great a quantity of ingredients will produce the same effect ; but in this the disengaged sulphuric acid concurs, as will be shewn.

Hence it follows, that when sumach is used instead of galls the proportion must be increased, without increasing that of the sulphat of iron, taking into the calculation the logwood that is used with it.

To obtain a fine black, it is of advantage to give the cloth a blue ground, as then a less quantity of the ingredients will be required to produce a deep tint, and consequently there will be less vitriol decomposed by the astringent particles. Now by this decomposition the sulphuric acid is disengaged ; and if it happen to be concentrated to a certain degree, it acts upon the stuff, diminishes its softness, and weakens it. It may even redissolve the
black

black particles which were fixed in it, or rather prevent them from fixing in sufficient quantity.

A ground of any other dark colour may be given, particularly fawn colour, but then the black will not be so fine.

In dyeing black, it is good to use a little verdegris; the oxyd of copper which it contains in greater or less quantity, favouring the precipitation of the black particles by combining with the sulphuric acid. Probably that part of the verdegris which is in the state of acetite of copper^{*} is serviceable in the same way, the oxyd of copper combining with the sulphuric acid, whilst the acetic acid is disengaged and assumes its place: but the acetic acid does not act upon the black particles. It appears from the experiments of Mr. Clegg, that the place of verdegris may be supplied by oxyd of copper precipitated from sulphat of copper, or blue vitriol; and no doubt any other oxyd of copper would do equally well.

The processes employed for dyeing wool would give only a rusty black to silk, as Lewis has observed. Let us examine the differences which distinguish the processes employed in dyeing silk.

^{*} See the chapter on Verdegris, part i.

Silk is much less disposed than wool to combine with the black colouring particles; and its union with them is much weaker, for the mineral acids, tartar, and alum, separate them much more easily from silk than from wool.

On the other hand, silk is much more disposed to combine with the astringent principle than wool. I have found by experience, that silk gains double the weight acquired by wool in the same galling. Some observations that I have made on this subject will not here be misplaced. Silk galled with white galls acquired more weight than silk galled with black: but an equal weight of the latter produced with sulphat of iron one fifth more of black precipitate, and silk treated with these galls gained in the dye-bath or *fat*, an increase of weight that compensated the deficiency of weight in the galling. Silk treated with a quantity of sumach double that of the galls was not so much increased in weight; but it acquired a little more in the bath, so that the ultimate difference of weight was inconsiderable.

It must be remembered, that the astringent has such an attraction for the black particles, as in a certain degree to take them from the wool with which they were combined. Hence it

it may be conceived how the astringent combined with a stuff, communicates to it not only the property of decomposing salts of iron to seize on their oxyd, but also of combining with the black particles already formed.

Silk, then, which has little attraction for the black particles, and much more for the astringent, ought to be first galled, which imparts to it the property of combining with the black particles. But though we may begin the dyeing of wool also by galling, this preliminary operation may be considered as at least useless, since the mixture of the astringent with the sulphat of iron will give it at once a fine black.

The slight disposition of the black particles to fix on silk explains the composition of the bath employed. This composition is by no means uniform. I have compared several receipts, and have found them so different, and all of them so complex, that I could make choice of none: but it appeared to me, that the end attained by them in different ways was to make a bath, in which the black particles very abundant and near together, should not be retained by an acid, and should be held but weakly by the liquor. Hence 1st, the use of litharge, verdegris, and iron filings put into the bath: 2dly, the utility of gummy and mucilaginous

luginous substances, which serve to prevent the black colouring particles, that ought to remain suspended in the bath, from subsiding: 3dly, the advantages of an old bath, in which the colouring particles are accumulated in large quantity, and feebly retained: for it has been seen, that the black particles formed by the mixture of sulphat of iron with an astringent, are not precipitated without difficulty, when the liquor is not diluted with a great deal of water.

This theory I have confirmed; and the following experiments have conducted me to a very simple process. It must be remembered, that operations in the small way require a larger proportion of the ingredients.

I galled an ounce of silk with an ounce of nut-galls, and made a bath with

Nut-galls.....	one ounce,
Logwood.....	one ounce,
Gum.....	two ounces,
.Sulphat of iron, or vitriol...	half an ounce,
Verdegris....	one dram twenty-four grains ^b .

The silk being taken out and aired, was put again into the bath twice, adding each time one dram twenty-four grains of sulphat of iron and

^b For a comparison of french with english weights see end.

two of verdigris : after this it was dipped in weak soap-suds. The black obtained by this process, was imperfect, and inclining to violet.

I repeated the operation with a bath composed of the same ingredients, but it was exposed to the air for twenty days before it was used, and the verdigris was not put in till the instant of going to dye. This time I had a fine deep black.

I repeated these experiments substituting sumach instead of galls ; but I used double the quantity of sumach, both for the galling and for the bath, without altering the quantities of the other ingredients ; and obtained an imperfect black in the first method, but in the second, as fine a black as with the galls.

This bath differs from that commonly used for hats, only in the proportions of the ingredients ; and indeed the residuum of the hatters bath is employed with success for dyeing silk stockings.

It appears to me beyond a doubt, that sumach may be used instead of galls for dyeing silk and hats, with the simple precaution of taking double the quantity of sumach : an important object, particularly at present when galls bear so high a price.

To explain in a satisfactory manner the difference of the processes employed for linen and cotton, to which, like silk, the black particles adhere but weakly, is far from easy: though I have found by experience, that cotton simply galled acquired only a blackish colour in the process which gave me a fine black with silk. I shall offer a few conjectures on this subject.

I have remarked, that the solution of sulphat of iron forms a precipitate when left exposed to the air, and that the iron in this case acquires a greater proportion of oxygen: but the solution in acetic acid, or other vegetable acids analogous to it, does not in similar circumstances form a precipitate, but only assumes a deeper hue. Besides, these acids take up a larger portion of iron than the sulphuric.

On the other hand, I have observed, that iron highly oxydated has a great attraction for linen and cotton, producing in them spots not easily discharged; and that in all the processes, the solution is directed to be left a long time exposed to the air, and even rusty old iron to be chosen.

Hence it appears to me, that the iron which is to enter into the composition of the black particles, ought to retain more oxygen to unite with linen and cotton, than to unite with wool
or

or silk : that a solution in vegetable acid, exposed a long time to the air, possesses this advantage : and that, besides, it leaves in the liquor that remains on dyeing, a weak acid, which does not act on the black particles.

This theory I sought to confirm by the following experiment. I dissolved iron in nitric acid, precipitated it by fixed alkali, and calcined it in a crucible. In this state it is known to be scarcely soluble in the sulphuric acid. With this calx I saturated vinegar as completely as possible, and dyed cotton, first alumed and afterwards galled, with the solution fresh made. After this first dyeing, I galled and dyed the cotton a second time ; when it had acquired as deep a black as the cotton to be met with in commerce, only it was a little harsh. A similar experiment made with sumach instead of galls, using double the quantity, was equally successful.

It is difficult to obtain a fine black on linen, or cotton ; but to come as near to it as may be, it is proper to give a blue ground as deep as possible, because then, a small quantity of colouring matter is sufficient to produce a black, and perhaps the indigo itself contributes to fix the black particles. For common blacks, however, this would be too expensive. The

galling is preceded by aluming, because the alumine, which is thereby fixed, renders the galling more effectual. The place of galls, which bear a considerable price, is frequently supplied by oak bark, oak saw-dust, sumach, the cups and husks of acorns, or other common astringents.

C H A P. III.

Of Gray.

THE shades of black are grays, from the deepest to the lightest.

Grays may be produced in two ways. In the first, a decoction is prepared from bruised galls, and the vitriol is dissolved separately. A bath is made proportionate to the quantity of stuff to be dyed of the lightest shade; and when it is so hot that the hand will just bear it, some of the decoction of galls, and some of the solution of vitriol, are poured in. Into this the wool or cloth is dipped. When it has attained the shade desired, it is taken out, and more of the decoction, with more of the solution, is added to the same bath. Into this more cloth

cloth is dipped, to give it a deeper shade than the preceding. In the same manner the operator proceeds to the deepest shades, always adding some of each of the liquors: though for black gray, and other deep shades, it is best to give the cloth previously a blue ground more or less deep.

The second method of producing gray, which Hellot prefers to that I have just described, because in it the stuff takes the decoction of galls more firmly, and there is a greater certainty of putting no more sulphat of iron than is necessary for the shade required, consists in boiling for two hours the proper quantity of galls, bruised and enclosed in a thin linen bag: in this bath the cloth is to be boiled for an hour, being kept stirring, after which it is taken out: a little solution of vitriol is then added to the same bath, and the cloth that is to have the lightest shade is dipped in it. For the deeper shades more solution of iron is added.

In either of these methods we may begin with the deepest shades, if we be not confined to patterns which must be suited exactly. In the latter case each piece of stuff should be left a longer or shorter time, till it has acquired the intended shade.

It is not possible to determine the proportions of the ingredients, the quantity of water, and the time necessary for all these operations: they must be judged of by the eye. If the bath be greatly loaded with colour, the wool must remain in it a less time: if, on the contrary, the bath begins to be exhausted, a longer time is required. If we find the stuff not dark enough, it must be re-dipped a second, a third time, &c. if it be too dark, it must be dipped into another hot bath, into which has been put a small portion of decoction of galls, or into a bath of soap-suds, or of alum. If in this operation we go beyond the mark, the colour must be darkened as before; but repeating these operations is prejudicial to the stuff, so that we should endeavour to catch the proper shade at once, by taking it out of the bath from time to time.

Care must be taken that the bath do not boil, and that it be rather warm than too hot. In whatever manner grays are dyed, they should be immediately washed in a large body of water, and the darkest should even be cleansed with soap.

It is frequently required to give grays a tint of another colour, as a nut, agate, or reddish
cast.

cast. In this case, having given a tint more or less blue according to the object intended, the stuff is dipped in the remains of some cochineal liquor, that has served for dyeing either scarlet or violet, adding to it galls, logwood, madder, &c. they are then browned more or less deep with solution of iron. For the nut-gray, yellow wood and logwood are added to the galls, and the stuff is dyed from white.

Silk takes all grays, except black gray, without previous aluming. The bath is composed of fustic, logwood, archil, and sulphat of iron. These ingredients are varied according to the tint to be given. Thus more archil is employed for grays that are to have a reddish cast, more fustic for those that should incline to a russet or green, and more logwood for those that are to be of a darker gray. For iron gray, logwood and solution of iron only are used.

Black gray requires aluming; after which the silk is taken to the river, and then dipped in the weld bath. A part of this bath is thrown away, and its place supplied with logwood liquor. When the silk is impregnated with this, a sufficient quantity of solution of iron is added, and as soon as it has acquired

acquired the proper shade, it is washed and wrung.

If the gray happens to be darker than it ought, the silk is dipped in a solution of tartar, and afterwards in warm water: and if by these means the colour be weakened too much, the silk is again dipped in a bath of fresh dye.

Linen and cotton have a blue ground given them for black-gray, iron-gray, and slate-gray, but for no other. All the shades require a galling proportionate to the gray to be produced. Gall-baths that had before served for other purposes are frequently used.

When the thread has been galled, wrung, and dried, it is dipped on the sticks in a tub of cold water, to which is added a proper quantity of the bath from the black cask, and of a decoction of logwood. The thread is worked in this pound by pound, washed, and dried.

Mr. Pileur d'Apligny gives two other processes for dyeing gray, which according to him, produce a more permanent colour.

1. The thread is galled, dipped in a very weak bath of the black cask, and then madder.

2. The thread is dipped in a very hot solution of tartar, wrung gently, and dried. It is then

then dyed in a decoction of logwood. After this operation the thread appears black ; but, on working it attentively in warm soap-suds, the surplus of the dye is discharged, and it remains of a pleasing and durable slate-gray.

SECTION II.

Of Blue.

CHAPTER I.

Of Indigo.

INDIGO is a blue colouring substance extracted from a genus of plants, known by the name of *indigoferæ*, and *indigo*.

At St. Domingo, and the neighbouring colonies, two species of *indigofera* are distinguished: the true and the bastard. The first is a somewhat bushy shrub, growing to the height of two or three feet: its leaves are round, pretty thick, small, and greenish: its flowers resemble those of the pea, and are succeeded by long curved pods.

When the *indigofera* appears to be ripe, it is cut, and carried to the vats, where it is to undergo a fermentation, to which it is greatly disposed. If it be perfectly ripe when cut, the indigo it affords is of a finer colour, but
 2 much

much less in quantity, than if it be not arrived at a state of maturity : if it be over ripe, the quantity is still less, and its quality is bad.

There are three vats placed one over another at different heights, and near a reservoir of water. The first is called the *steeping vat* (trempoire). Into this the plant is put, after having filled it with water to a certain height : a brisk fermentation soon commences ; and much scum is formed. Mr. Quatremere says, that the disengaged gas is inflammable.

When the indigo-maker finds the fermentation sufficiently advanced, and the colouring particles beginning to unite, he draws off the liquor into the second vat, called the *beating vat* (batterie) in which the liquor is beaten with instruments contrived for that purpose. Mr. le Blond asserts, in the observations sent by him to the academy of sciences, that this operation is intended to dissipate the carbonic acid formed by the fermentation, which would prevent the precipitation of the colouring particles. He says, that the beating is not sufficient to procure the precipitation of all the colouring particles, and that a method has been tried in french Guiana, which, by producing a much more copious precipitate, revived the hopes of the colourists, who were abandoning

abandoning this manufacture. This method consists in mixing with the liquor a quantity of lime-water, which absorbs its carbonic acid : but he thinks, that this should not be carried beyond a certain proportion, and that an excess of lime-water is prejudicial. This method is not new : it is mentioned by father Labat. Mr. Struve also has thought, that lime-water would favour the precipitation of the indigo, by seizing the carbonic acid which held it in solution ^a.

When it is judged from the blue colour, that the liquor is sufficiently beaten, it is left at rest about two hours, that the colouring particles may begin to separate from the liquor, which contains a yellow extractive matter, and it is then drawn off into a third vat, called the *settling vat* (diablotin). The colouring particles are left to settle in this vat, the supernatant liquor of which is drawn off by two cocks placed one above the other ; after which the colouring particles, then in a state of semi-fluidity, are drawn off by a third cock into a linen strainer in the shape of a jelly-bag ; and when they are reduced to the consistence of a paste, they are turned out into square

^a Bibliotheque medico-physique du Nord. tom. iii.

boxes, placed in the open air, under sheds which shelter them from the sun.

The indigo produced in these operations differs, not only according to the quality of the plant which afforded it, but according to the care employed in its preparation. Its colouring part however, appears to be invariably the same; so that the difference of its quality is entirely owing to the heterogeneous substances mixed with it, and the degree of consistence which it acquired in dyeing.

There is a light sort that comes from Guatimala, of a fine blue colour, and called *light indigo*, or *flower indigo* (indigo fleur). It swims on water, whilst all the other kinds sink in it. This sort is the finest and most valuable. There is a sort known by the name of *coppery indigo*, because its surface assumes a copper colour when rubbed against a hard body; and there are other sorts much less pure, as that which comes from Carolina.

In the experiments of Bergman^b, one part in nine of indigo was found to be soluble in water by boiling. This part appeared to consist of mucilaginous, astringent, and saponaceous particles. The astringent particles are

^b Chemical analysis and examination of indigo.

precipitable by solutions of alum, of sulphat of iron, and of copper.

Mr. Quatremere ^c also has separated the soluble parts by means of water. He asserts, that their quantity is greater in proportion as the indigo is inferior in quality ; and that the residuum, after this operation, is equal to the finest indigo : whence he proposes, to purify indigo of inferior quality, by boiling it in a bag, renewing the water till it will take no more colour. Unquestionably this operation would be of advantage, as it would deprive the indigo of the yellow matter capable of altering its colour : still however, its quality might differ, on account of the earthy particles not soluble in water, which it is true, could not affect its colour, but would vary the proportion of the colouring matter.

Powdered indigo digested in alcohol gave a tincture at first yellow, then red, and at last brown. By this operation several times repeated, it lost about a seventeenth of its weight. From this tincture water separated a brownish resinous substance.

^c Analyse & examen. chym. de l'indigo, tel qu'il est dans le commerce pour l'usage de la teinture.

Ether acts on indigo nearly in the same manner as alcohol ; but oils, either fixed or volatile, have little action on it.

Bergman mixed one part of indigo finely powdered, with eight parts of colourless sulphuric acid, so concentrated, that its specific gravity was to that of distilled water, as 1900 to 1000. The glass vessel in which these were mixed was slightly stopped. The acid attacked the indigo readily, and excited great heat. After twenty-four hours digestion, the indigo was dissolved, but the mixture was opaque and black : by the addition of water it was rendered clear, passing successively through the various shades of blue, in proportion to the quantity of water. At least twenty pounds of water are required to render the smallest drop of the solution imperceptible, in a cylindrical glass vessel of seven inches diameter.

If the sulphuric acid be diluted with water, it attacks only the earthy principle mixed with the indigo, and some mucilaginous particles.

Several bottles in which a drop of this solution was mixed with liquors containing different substances, as acids, alkalis, and neutral salts, were exposed for some time to a temperature of from fifteen degrees to twenty degrees (65 to 77 Farh). In some the colour remained

unaltered ; in others it became green, and was destroyed more or less readily. Bergman accounted for the changes he observed, by the property some substances possess of taking away phlogiston, and others of affording it : but they may be happily explained by the attractions of oxygen, which some substances yield, or take away, or acquire from the atmosphere.

Fixed alkalis saturated with carbonic acid separate from the solution of indigo a very fine blue powder, which is deposited very slowly. Bergman distinguishes this blue powder by the appellation of *precipitated indigo*. It may be obtained also by dropping the solution into alcohol, or into saturated solutions of alum, sulphat of soda, or other salts containing the sulphuric acid, but the liquor remains always in some degree coloured.

Concentrated nitric acid attacks indigo with such violence as to set it on fire. If it be diluted to a proper degree, it acts with less vehemence, the colour of the indigo becomes rusty, and the residuum, which amounts only to one third of the indigo employed, has the appearance of umber. Fixed alkali precipitates from the nitric acid which has acted on the indigo, a little oxyd of iron, mixed with barytes and

and calcareous earth : but if too much alkali be added, a part of the precipitate is redissolved, and the colour of the liquor becomes deeper than before.

Bergman says, that the nitroüs acid which has been *phlogisticated* by indigo, and has at the same time taken up a portion of its mucilage, may be employed for dyeing wool or silk of different shades, of a very permanent yellow : but here that great chemist mistakes for a particular effect, the action always exerted by nitric acid on wool or silk, to which it gives a yellow colour, more or less deep according to its degree of concentration, and which he has himself described in his notes on Scheffer's essay on dyeing.

Mr. Hauffman has given a more regular series of observations on the changes produced in indigo by nitric acid, in an interesting dissertation^d, inserted in the *Journal de Physique* for March 1788. After all the indigo which he had exposed to the action of that acid appeared to be destroyed, he found in the vessel a coagulum, which, being perfectly freed from nitric acid by washing, formed a brown viscous mass, having all the appearance of a gummy

^d Sur l'indigo & ses dissolvants.

resinous substance : it was soluble in alcohol, which indigo is not, and was not soluble in water, except in a large quantity, though more so in hot water than in cold : and it was very bitter to the taste. The water with which the coagulum had been washed, yielded on evaporation small crystals, which exhibited many properties of the tartarous and oxalic acids, but the nature of which our author did not precisely ascertain.

Muriatic acid, digested and even boiled on indigo, takes up the earthy part, the iron, and a little extractive matter, which colours it of a yellowish brown, but has not the least action on the blue colour. If the indigo be precipitated from sulphuric acid, the muriatic acid will readily dissolve a certain portion of it, and form a deep blue liquor.

The other acids, as the tartarous, formic, acetous, and phosphoric, act on indigo like the muriatic : they dissolve precipitated indigo very well. Sulphuric acid too much diluted with water to dissolve indigo, and nitric acid also when too weak to decompose it, dissolve only the earthy part and the extractive matter, which are altogether foreign to the colouring substance.

The oxygenated muriatic acid shews little action on indigo in substance, but destroys its colour when in a state of solution. I employed the solution in sulphuric acid to ascertain the alterations it would induce in it. With this I mixed oxygenated muriatic acid, till its blue colour was entirely destroyed: it was then of a brown yellow. In this state I evaporated it, and a blackish viscous substance was gradually deposited, which appeared to be of the same nature as that Mr. Hauffman obtained by means of the nitric acid.

This effect of the oxygenated muriatic acid on the solution of indigo in sulphuric acid, affords a very accurate method of determining the goodness of indigo. All the colouring particles contained in it are soluble in the sulphuric acid, and form perfectly similar solutions, for there is no difference between the colouring particles. The relative quantities therefore, of these particles contained in different specimens of indigo may be found, by the proportions of oxygenated muriatic acid required to destroy the colouring particles extracted by sulphuric acid from equal weights. In the second section of the first part of this work, I have mentioned the precautions necessary in making this experiment.

Pure or caustic fixed alkali dissolves some substances foreign to the colouring matter of indigo, but acts little on the colouring matter itself. Caustic volatile alkali or ammoniac, acts nearly in the same manner. Precipitated indigo dissolves readily without heat, in alkalis, fixed or volatile. If they be pure or caustic, the blue colour changes gradually to a green, and is at length destroyed: but if they be combined with carbonic acid the colour is not altered. Lime-water has little action on indigo itself, but it dissolves precipitated indigo. This solution changes its colour, which is ultimately destroyed, nearly in the same manner as those in caustic alkalis.

Indigo exposed to the action of fire in an open crucible, or under a muffle, fumes, swells, grows red, and sometimes takes fire, emitting a white flame. A hundred parts of indigo leave thirty-three or thirty-four parts of ashes.

These ashes afford no fixed alkali when lixiviated with distilled water. Muriatic acid dissolves the greater part of them with a slight effervescence: the residuum, which is insoluble, constitutes an eleventh part, and has the characters of siliceous earth.

The solution in muriatic acid produces prussian blue, on mixing with it prussiat of pot-ash.

From

From thirty to thirty-two grains (25 to 27 English) are obtained from the ounce of indigo. Bergman concluded that the ounce contained eighteen or twenty grains (15 or 16) of iron: but he has ascertained in various subsequent works, that prussian blue formed by means of prussiat of pot-ash, contained only about a sixth of its weight of iron; so that from the above experiment we should reckon only five or six grains (4 or 5) in the ounce.

Beside the iron and siliceous earth, the ashes contain calcareous earth and barytes.

Indigo detonates strongly with nitre. In distillation it affords carbonic acid, a liquor containing a little volatile alkali, and an oil resembling the empyreumatic oil of tobacco, and readily soluble in alcohol.

Bergman concludes from his analysis, that a hundred parts of good indigo contain,

Mucilaginous matter separable by means of water.....	12
Resinous matter soluble in alcohol.....	6
Earthy matter soluble in acetic acid, which does not attack the iron here in the state of oxyd.....	22
Oxyd of iron soluble in muriatic acid..	13

The forty-seven parts remaining are almost pure colouring matter, which, distilled alone, affords

Carbonic acid	2
Alkaline liquor.....	8
• Empyreumatic oil.....	9
Coal.....	23

The coal burnt in the open air, gave four parts of earth, about half of which was oxydated iron, and the remainder a very fine filiceous powder.

From these results, that great chemist considers indigo as a substance analagous to prussian blue, and the colouring parts of ink. He thinks that, like those substances, it owes its colour to iron : but it has been shewn that the method used by him to calculate the iron contained in it, exaggerated its quantity. Besides, we should reckon only that iron which enters into the composition of the colouring matter ; for that which the muriatic acid can dissolve without attacking the colouring matter, ought to be considered as a foreign substance, as well as the earths and extractive and resinous matters, the quantities of which vary greatly in different kinds of indigo. Now from forty-seven parts of pure indigo, Bergman obtained only two parts of oxyd of iron, which owes at least



least a fourth of its weight to oxygen. Hence it follows, that iron cannot be reckoned more than a thirtieth part in the composition of the colouring matter of indigo, the properties of which, moreover, appear to have but a very slight relation to those of prussian blue, and the colouring parts of ink. Iron then, can have but little influence in producing the colour of indigo.

It is known at present that most of the principles obtained by distillation, as oil, carbonic acid, and ammoniac, did not exist in the substance from which they are disengaged by heat; but that they are new combinations, owing to principles, which, by their union, formed the original substance. Thus there is neither oil, nor ammoniac, in indigo: but from the products of its analysis we may conclude, that it contains a pretty considerable quantity of hydrogen, a little azot, a very small quantity of iron, but above all, such a proportion of coal as is obtainable from no other known vegetable substance, since forty-seven grains of pure indigo left twenty-three of coal, from which, it is true, we are to subtract four grains of ashes, but then on the other hand, we must add the coaly matter contained in the oil, in the carbonic acid, and in the carbonic hydrogenous gas,

gas, which was no doubt disengaged in the operation. Other experiments will shew, that oxygen really exists in indigo, without forming such an intimate combination as when it enters into the composition of water. As to the siliceous earth, it does not appear whether it be a component part of the colouring matter, or simply mixed with it.

The great quantity of coal and of hydrogen which enter into the composition of indigo, account for its prompt inflammability, and the brisk detonation it produces with nitre. The nitric and oxygenated muriatic acids appear to me to produce the blackish viscous substance before mentioned, by forming water from a combination of their oxygen with the greater part of the hydrogen of the indigo, so that the coal matter remains combined with only a very small portion of hydrogen.

In the first part of this work I have exhibited the reasons which to me seem to prove, that the fixity and unchangeableness of colours are chiefly owing to the proportion of fixed principles which enter into the composition of the colouring matter, and the abundance of coal, which, combining with oxygen less readily than hydrogen does, gives them the property of resisting the action of the air.

In

In indigo we find this abundance of coal which must render its colour fixed and unchangeable. Forty-seven parts of pure indigo left on distillation twenty-three of coal, in Bergman's experiments : and Mr. Quatremere says, that four ounces of indigo yielded him two ounces and a half of coal. If we turn our attention to the preparation by which it is extracted, or rather formed, it appears, that the substance to which it owes its origin must have been of a resinous nature when in the organized plant : that in the preparation it has undergone, in the kind of putrefaction it has experienced, a part of its hydrogen has been consumed by a slow combustion, during which a gas escaped : and that the chief use of the heating was to favour the contact and action of the air. This theory is confirmed by the circumstances which accompany the heating : if it be continued too long, the indigo is changed, blackened, and *becomes what is called burnt indigo* ^c.

Indigo has not indeed the brown or fawn colour, which most commonly indicates that combustion of which I have laid down the theory : but I have remarked, that this colour

^c Hist. philos. & polit. des établ. &c. livre vi.

is not an inseparable effect of it, for colours are influenced by slight circumstances : besides, a deep blue approaches considerably the proper colour of coal.

I have advanced, that when colouring matter like that of flax underwent a slight combustion, a small portion of oxygen remained united with it, without combining particularly either with the hydrogen or with the coal, and that hence arose some of its qualities. It appears, that we find in indigo this property, which remains to be examined ; and from this it is, that the putrefaction, or rather combustion, which it undergoes in its preparation, must have a certain limit, which if exceeded, the indigo is rendered of bad quality.

It has been seen that indigo is not naturally soluble, either by alkalis or lime, yet in the processes employed, it is dissolved by those substances, from which it is afterwards precipitated on the matter to be dyed. The solution of indigo by lime or alkali is greenish. At the surface it becomes blue, because there the indigo is precipitated in its natural state. The green colour is not produced by the alkalis, as it is in many other blue vegetable substances, as Bergman observes : for these, when rendered green, recover their colour as soon as the
alkali

alkali is saturated with an acid, which of itself would give them a red colour : but an alteration of the colouring matter of indigo was requisite to its solution in an alkali, and acids have not the property of making it red. It remains to inquire what change the indigo experiences previous to its solution in alkalis.

Bergman examines two processes, to deduce from them the cause of the changes produced in the indigo. When we treat of these as operations of the dyer, we shall consider them more minutely : at present it is sufficient merely to mention them. If sulphat of iron be mixed in water with an equal weight of indigo, and double its weight of lime, the indigo soon dissolves : but Bergman has observed, that if the sulphat of iron be boiled for some hours in a large portion of water, afterwards reduced to a proper quantity by evaporation, the solution would not take place. If a solution of pure or caustic fixed alkali be taken, and to this indigo and sulphuret of arsenic or orpiment be added, the bath soon becomes green, and the indigo is dissolved. If instead of the sulphuret of arsenic, we substitute the portion of arsenic it contains, the bath will never be fit for dyeing ; but on adding the quantity of sulphur it
ought

ought to contain, we shall soon see marks of solution.

Bergman attributes these effects to phlogiston, communicated to the indigo in the first instance by the precipitate of iron, in the second by the orpiment, by means of which it is rendered soluble by the alkali and the lime ; so that when the precipitate of iron has been deprived of its phlogiston by a long ebullition, it is unable to occasion a solution of the indigo, because it is no longer capable of affording it phlogiston.

In this explanation we have only to make those alterations which are pointed out by the improvements made in physics. Indigo contains a portion of oxygen, which may be taken from it by substances that have a strong attraction for it, and then it becomes soluble by lime and alkalis. The fresh precipitate of sulphat of iron is a substance of this kind : for it is known from the experiments of Dr. Priestly, that this precipitate combines with vital air with which it is placed in contact, whilst its green colour changes to a red, and then to a yellow ; but by a long ebullition the iron combines with more and more oxygen, and at length becomes saturated with it, thus being rendered incapable of taking it from the indigo.

digo. Sulphuret of arsenic also, when dissolved in an alkali, has a strong attraction for oxygen; but the oxyd of arsenic has a very slight tendency to combine with that principle.

Mr. Hauffman has proved by a direct experiment, that the solution of sulphuret of arsenic mixed with indigo absorbed vital air, with which it was in contact: for having put some of that solution, known in the dye-house by the name of *printing blue* (bleu d'application) in contact with air obtained by distilling nitre, seven eighths of the air were absorbed, and the residuum was found to be azotic gas. The printing blue was entirely spoilt, and the indigo was regenerated: a portion of the alkali united with the sulphuric acid produced, and formed with it sulphat of pot-ash: there remained some caustic alkali, and the arsenic, instead of being in the metallic state, as it is in the sulphuret of arsenic, was combined with it in the state of oxyd. Perhaps Mr. Hauffman would have found, that a part of the arsenic was in the state of an acid, had he pursued his inquiries with more accuracy.

Though with respect to the theory of this observation, Mr. Hauffman remains undecided whether to adopt the phlogistic hypothesis, or the natural explanation which attributes the phenomena

phenomena just described, to the absorption of air and the combination of oxygen, no doubts of the validity of the latter can remain at present, when it is known that the air obtained from nitre is composed of vital air, and a more or less considerable proportion of azotic gas or phlogisticated air, according to the degree to which the decomposition of the nitre has been carried. The azotic gas, which Mr. Hauffman found as a residuum, was preexistent then, and had no share in producing the phenomenon: the vital air was simply absorbed by the sulphur, which was converted into sulphuric acid: it combined also with the arsenic, reducing it to the state of oxyd, and perhaps even of an acid; while a portion of it united likewise with the indigo dissolved by the caustic alkali: hence the indigo resumed its blue colour, and its natural state; the caustic alkali was no longer capable of acting on it; and it was precipitated: circumstances perfectly analogous to those which take place in the solution of indigo produced by means of sulphat of iron.

It follows from what has been said, 1st, that indigo in its natural state contains oxygen: 2dly, that while it retains this oxygen it is incapable of uniting with alkalis or lime: 3dly, that
that

that substances capable of depriving it of this portion of oxygen render it soluble by lime and alkalis: 4thly, that this solution is decomposed, and the indigo resumes its natural state, when it comes into contact with atmospheric air, and attracts the oxygen of which it had been deprived. The very same things happen when any substance is dyed in the indigo vat. In the vat it acquires a green colour; but when it is exposed to the air it becomes blue, because the indigo recombines with the oxygen it attracts from the atmosphere, by which it is restored to its natural state, and the lime or alkali is set at liberty: the latter being carried off in the washing, the indigo remains combined with the substance, which is found to be dyed by its means. I have found, that a pattern of cloth, or cotton, coming green out of the vat, acquired in like manner a blue colour, by dipping it quickly into oxygenated muriatic acid, sufficiently diluted not to decompose the indigo.

With respect to Mr. Hauffman's experiment I shall observe, that the sulphuret of alkali and of arsenic acts much more powerfully on oxygen than the simple sulphuret of alkali; which may be owing to two causes: 1st, the arsenic, which in the sulphuret of arsenic is in the me-

tallic state, or very slightly oxydated, may itself act on the oxygen: or 2dly, the union of the sulphur and alkali may not be so intimate in the triple compound of alkali, arsenic, and sulphur, as in the more simple sulphuret, composed of sulphur and alkali only; so that the sulphur existing in a state of equal division may act more strongly on the oxygen.

However this may be, on the more powerful action exerted on oxygen by the sulphur of alkali and of arsenic depends the more striking effect it produces on wines that contain lead; because it thereby reduces nearer to the metallic state the oxyd of lead, which thence acquires a blacker colour.

It has been seen, that indigo underwent from the action of the nitric and oxygenated muriatic acids a combustion, in which its hydrogen was alone, or at least principally, destroyed. Sulphuric acid in dissolving it, appears also to produce a slight combustion, which is perceived by the smell of sulphureous acid, however gentle the heat by which the solution is effected. If the heat employed be a little too great, the signs of combustion are very evident. To this alteration I attribute the changes observed by Bergman in the indigo precipitated from sulphuric acid. Thus, pure alkali and lime dis-
solve

solve the precipitate, render it green, and soon destroy its colour, so as not to be recoverable by acids, because, as I have shewn, they favour the progress of the combustion. If the liquor which is deprived of its colour were evaporated, a residuum of the nature of that left by the nitric and oxygenated muriatic acids would probably be obtained.

Indigo, when it has undergone a slight alteration from the sulphuric acid, does not adhere so strongly to wool or silk, as when it is in its natural state. Hence the *saxon blue*, produced by a solution in sulphuric acid, is less permanent than the blue of the indigo vat; and that solution is capable of giving only a slight dye to silk, and a still slighter to thread or cotton.

If we attend to the properties acquired by indigo when deprived of a portion of its hydrogen, as it is by the oxygenated muriatic acid, it will not be difficult to explain the greater part of the observations made by Bergman on different mixtures with solution of indigo.

Mr. Hauffman has observed, that the sulphuret of antimony, or crude antimony, promoted the solution of indigo, in the same manner as sulphuret of arsenic; but that the oxyd of antimony mixed with sulphur would not

produce the same effect. He remarked, that the solution of indigo by means of sulphuret of antimony could not be used as a printing blue, *couleur d'application*, because the antimony was precipitated in a red state, probably remaining combined with a little sulphur. Other metallic sulphurets did not succeed with him; because, as he observes, they are not soluble in caustic alkali.

We are indebted to Mr. Hauffman for many other interesting observations, which I am not yet able to explain in a satisfactory manner. He digested a mixture of iron filings reduced to a fine powder, indigo ground with water, and concentrated caustic alkaline liquor, without being able to dissolve the colouring substance: but a very good solution was procured by means of antimony in its metallic state. The oxyds of antimony appeared to have no action on it; and zinc, though it acts strongly on oxygen, produced no solution.

The precipitate of copper with indigo exhibited to him some peculiar phenomena. Far from contributing to its solution, it effected its regeneration from all the different arsenical and antimonial solutions, as well as from that obtained by means of precipitate of iron. The solution of copper in ammoniac produces the
same

same effect. He says, that the dyers avail themselves of this property of copper, more readily to exhaust the blue vats, which, from having been too long in use, or containing originally too little indigo, give but very weak shades; but on dipping the goods to be dyed into a water very slightly impregnated with sulphat of copper, or other coppery solution, whether acid or alkaline, deeper shades are obtained.

C H A P. II.

Of Pastel and Woad.

PASTEL is a plant of the family of the cruciferæ, the distinguishing character of which is taken from the form of the seed-pod, which is flat like that of the ash, edged with a thin membrane, and contains two long seeds. Two species are distinguished: that which is cultivated, *isatis tinctoria*, Lin. and the portuguese pastel, *isatis Lusitanica*, Lin. which differs from the former in being smaller and having a narrower leaf. The former species puts

out stalks three feet high, of the thickness of a man's finger, which divide into a number of branches, abounding with large lanceolated leaves, of a blueish green colour, the margins of which have little smooth indentations. The flowers are yellow, disposed in panicles on the summits of the stalks. The root is large, woody, and penetrates deep into the earth.

This plant requires a good black earth, light, and well manured. It is sown in February, March, or April, after two ploughings in autumn. It affords three or four crops a year: the first when the stalks begin to grow yellow, and the flowers are ready to appear; the others at intervals of six weeks, or more, according to the climate and warmth of the season.

The plant is mown, washed afterwards in a river, and dried in the sun. Care must be taken, that it dry speedily; for if the season be unfavourable, or it should rain, the plant is in danger of being spoiled: one night is sometimes sufficient to turn it black.

The plant is next carried to the mill to be ground, and reduced to a paste. Of this are formed heaps, which are covered so as to secure them from rain. At the end of a fortnight the pastel heap is opened, and beaten so as to mix the crust formed on the surface with the
inner

inner part. It is then made into round balls, which are carried to a place exposed to the wind and sun, that they may be deprived of their moisture, which would render them liable to putrify. These balls, heaped upon one another, grow hot by insensible degrees, and exhale a smell of volatile alkali, which is stronger in proportion as the quantity is larger, and the season warmer. The heat that has commenced is increased by watering the heap slightly, till the pastel is reduced to a coarse powder. It is in this state we find it in commerce.

Pastel is cultivated and prepared chiefly in Languedoc, Provence, and Normandy. That of Languedoc is most esteemed. In Normandy it bears the name of woad, differing from the common pastel only in requiring a larger quantity to produce the same effect, as Hellot has experienced.

Pastel gives, without indigo, a blue colour, which has no lustre, but is very permanent. As it affords much less colouring matter than indigo, and as its colour is inferior in beauty, the discovery of indigo has greatly diminished the cultivation and sale of pastel.

Astruc says, in his *Memoirs on the Natural History of Languedoc*, that on treating pastel in small quantity, in the same manner as anil

is treated for obtaining indigo, he procured from it a powder which produced the same effects as indigo does. From this Hellot has concluded, that the deep green colour of many plants is owing to blue and yellow particles, and that if we could destroy the yellow by fermentation, the blue would remain. But Lewis says ^a, that having caused herbs of different kinds to putrefy in water, he obtained no blue feculæ. I have already observed, that the supposition of a mixture of blue and yellow particles to form the green of plants, is destitute of foundation.

It appears, that the scheme of extracting indigo from pastel has been carried into execution in Germany. Mr. Gren thus describes the process employed ^b. Fresh leaves of pastel are washed in an oblong vat, nearly three parts filled, to cleanse them from the earth and filth: to prevent the water from raising them up, they are kept down with cross pieces of wood: on these leaves a sufficient quantity of pure water to cover them completely is poured, and the vessel is placed in a moderate heat: in a

^a The chemical works of Caspar Neumann, by William Lewis.

^b *Crell's neueste Entdeckungen*. A french translation is to be found in the *Bibliothèque medico-physique du Nord*, tom. iii.

longer or shorter time, according to the temperature of the atmosphere, a plentiful scum forms on the surface of the water, which indicates the commencement of the fermentation. By degrees the surface becomes covered with a blue pellicle, presenting to the eye tinges of a coppery hue. When there is a certain quantity of this scum, the liquor, which is of a deep green colour, is drawn off into another oblong vat, by means of a cock placed just above the bottom, or it is laded out to be put into the other vat. In either case it is necessary to pass it through a cloth, to separate the impurities, or bits of leaves, which might otherwise be mixed with it. The leaves are then washed with cold water, to remove any portion of the coloured pellicle which may adhere to them, and this water is mixed with that before drawn off. After this, lime-water is poured into the fermented pastel liquor, in the proportion of two or three pints to every ten pounds of leaves, and the liquor is stirred briskly for some time, to facilitate the separation of the indigo, which is deposited by standing. To know whether the stirring has been continued long enough, a little of the clear yellowish liquor is put into a common bottle, and shaken strongly : if any blue matter
separate

separate from it, the liquor must be again stirred. When all the indigo is separated, and has fallen to the bottom, the clear water is drawn off through a cock placed a little above the bottom of the vat, or by means of a siphon. This should be done without loss of time. To facilitate the separation of the water, the vat may be inclined towards the cock, as soon as the stirring is finished. The blue colour which remains is put into conical filters of linen, or Hippocrates sleeves. As a little of the colour always runs through these at first, the liquor should be received in a vessel placed beneath, and returned into the filter, till the water comes off clear. The indigo contained in the filters is to be edulcorated with a sufficient quantity of water, and dried in the shade, or with a gentle artificial heat, taking care to keep it covered.

Indigo may be obtained without the addition of lime-water, but not in so large a quantity. If a greater portion of lime-water be used, the quantity of the indigo will be increased, but its quality will be inferior, because the surplus of calcareous earth will unite with it. Alkaline salts likewise facilitate the separation of the blue colour : but it would not be advantageous employ them, because they afterwards dissolve

solve a part of it. No precipitate is occasioned by the addition of an acid.

It is necessary that a certain time be suffered to elapse, before the water which has fermented with the pastel leaves is drawn off. If it be drawn off too soon, little indigo will be obtained : if the leaves be left too long in infusion in the water, they readily enter into a state of putrefaction, emit a peculiar putrid and volatile smell, and the precipitate is no longer separable, the water remaining constantly green. It is the same with the water drawn off, if it be neglected ; and even when the indigo is already separated from the liquor, care must be taken to prevent it from running into putrefaction, which would occasion the loss of the whole, or at least, part of the indigo.

We must not however, be too hasty in turning the water into the vat in which it is to be stirred, at the first appearance of the changeable blue pellicle, since that is the time when it is acquiring most indigo.

When the heat of the atmosphere is considerable, the fermentation takes place very readily, and from fifteen to eighteen hours are frequently sufficient. Under such circumstances we must be particularly attentive not to suffer it to go on to a complete putrefaction. If the
heat

heat of the atmosphere be too slight, no great quantity of scum, or of the blue pellicle, will be perceived, but the liquor will insensibly incline to putrefaction, without exhibiting any very decisive marks of it previous to its commencement.

The plant bruised, or its juice, ferments more speedily, but affords only a dull blue.

The indigo obtained from pastel must be dried in the shade, because the sun destroys its colour.

Mr. d'Ambourney, who appears not to have been acquainted with the preceding experiments, has also sought methods of making indigo from pastel *. He succeeded by letting fresh leaves of pastel ferment in a certain quantity of water; taking out the leaves, and pouring solution of caustic alkali into the liquor; and afterwards filtering. The fecula remaining on the filter he compared to Carolina indigo. Thirty-five pounds of fresh ripe pastel leaves afforded him eight ounces of fecula.

* Supplément au Recueil des procédés d'expériences, &c.

C H A P. III.

*Of Dyeing in the Blue Vat with Indigo,
and with Pastel.*

DIFFERENT processes are employed for dyeing blue by means of indigo. These I shall briefly mention, without entering minutely into the particulars, which are well known in the dye-house, and most of which are carefully described in the work of Hellot.

The preparation for dyeing blue is not made in a copper, like those for other colours, but in a large wooden vessel called a vat. This is sunk into the ground so as to be only breast high above it. As it is of moment to preserve the heat of the vat, it is not fixed in the same place as the coppers, which require a free circulation of air, but in a place adjoining, constructed in such a manner as to retain the heat. This place is called *guesdre*; and the men that work the vat, who ought to be instructed by long experience to prevent the accidents to which it is liable, are called *guesdrons*.

Blue may be dyed with pastel or woad ; which would give a permanent, though not deep blue ; affording only a small quantity of colouring matter, as has been said in treating of those substances. But if indigo be mixed with them, vats will be obtained very rich in colour ; and these are almost the only ones used for wool or woollens. They are distinguished by the name of pastel vats.

Hellot has not accurately determined the proportions of the substances employed : I shall therefore borrow my description of a vat of this kind from Mr. Quatremere. It is to be observed however, that the proportions vary, not only in different dye-houses, but according to the shades required.

Into a vat of seven feet (French) deep, and five in diameter, are thrown two balls of pastel, weighing together four hundred pounds, first breaking them.

Thirty pounds of weld are boiled in a copper for three hours, in a sufficient quantity of water to fill the vat. When this decoction is made, twenty pounds of madder, and a basket full of bran are added, and it is boiled half an hour longer. This bath is cooled with twenty buckets of water, and after it is settled, the weld is taken out, and it is poured into the vat.

vat. All the time it is running in, and for a quarter of an hour after, it is to be stirred with the rake.

This being done, the vat is covered up very hot, and let stand six hours, when it is uncovered, and raked again for half an hour. This operation is repeated every three hours.

When blue veins are perceived on the surface of the vat, what is called *its ground* is given it, that is, eight or nine pounds of quicklime. As soon as this substance is put in, new appearances are perceived: the colour of the vat becomes a blacker and deeper blue, and its exhalations more acrid.

Immediately after the lime, or at the same time with it, the indigo is put into the vat, being first ground in a mill with the least possible quantity of water. When it is diluted to the consistence of thick pap, it is drawn off through a cock at the lower part of the mill, and thrown into the vat without any further preparation. The quantity of indigo to be used, depends on the shade to which the wool or cloth is to be brought: from ten to thirty pounds may be put into a vat composed in the proportions above mentioned, without the least inconvenience.

If on striking the vat with the rake, a fine blue scum called flower (*fleurée*) be obtained, nothing more is requisite previous to dyeing, than to stir it with the rake twice in the space of six hours, that the ingredients may be thoroughly mixed. Sometimes it is necessary to add a little lime.

The bath when first poured on the pastel is boiling hot; and care is taken not to leave the vat exposed to the air, except the time necessary for stirring it. As soon as that operation is over the vat is covered with a large wooden lid, on which thick cloths are spread, and every method of preserving its heat, without the assistance of fire is employed. Notwithstanding these precautions, however, favoured too by the construction of the *guesdres*, the heat can be kept up for a certain time only. At the end of eight or ten days it is greatly lessened: and will at length be entirely dissipated, if the liquor be not reheated.

This operation consists in pouring the greater part of the liquor of the vat into a copper, under which a large fire is made. When this bath is sufficiently hot, it is returned into the vat as before, and carefully covered.

The pastel vat is liable chiefly to two accidents. In the one it becomes *repelled* (*roide*,

(*vide, ou rebutée*) in the language of the *guesdrons*. This is found to be the case, when on uncovering a vat that has already afforded fine shades of blue, it appears black, without any blue veins, without flower (*fleurée*): if it be stirred, the black colour grows deeper and deeper, and the smell, instead of being somewhat sweetish, as it is when the vat is in a proper state, affects the nose with a very pungent odour. If an attempt be made to dye with a vat exhibiting these marks, the stuff takes no colour, or comes out of a dirty gray. These bad qualities are owing to an excess of lime; and Mr. Quatremere says, that he has imparted them to a vat, by putting too much lime into it.

The *guesdrons* employ different means to recover a repelled vat. Some put into it tartar, bran, urine, or madder: others content themselves with reheating it. The best remedy, according to Hellot, is to put in bran and madder at discretion. If it have but a little too much lime, it is sufficient to leave it at rest five or six hours or more, putting in only a certain quantity of bran, and three or four pounds of madder, which are to be sprinkled on the surface, when it is to be covered, and tried after a due interval. If it be repelled to

such a degree as not to give a blue but when it is cold, it must be left to recover without disturbance; and sometimes it must remain whole days without being stirred with the rake. When it begins to afford a tolerable pattern, the bath must be reheated. In general this revives the fermentation: or it may be excited with bran and madder, or even with a basket or two of fresh pastel.

Messieurs d'Orval and Ribeaucourt * advise, merely to let the vat rest without raking, if it be but slightly repelled: but if it be so in a considerable degree, to put in a few pounds of bran enclosed in a bag, at the same time sprinkling in three or four pounds of powdered tartar. In five or six hours the bag, which rises to the top, is to be taken out, and the vat raked. If it be not yet recovered the process is to be repeated.

Mr. Quatremere says, that to recover a vat, which he had repelled by overloading it with lime, he contented himself with reheating it twice, leaving it at rest afterwards two days, when it gave a well-marked flower. After this he let it stand three days, reheated it a third time, and found it to be recovered.

* Mémoire sur l'indigo, tel qu'il est dans le commerce, pour l'usage de la teinture.

The second accident to which the pastel vat is liable is putrefaction. When this happens, the veins and flower disappear, the colour of the vat becomes ruddy, the paste rises from the bottom, and a fetid smell is emitted.

Mr. Quatremere asserts, that a pattern of a deep blue plunged into a vat in this state, becomes several shades lighter. Putrefaction takes place in the vat because it has not been sufficiently supplied with lime. As soon as signs of putrefaction appear, we should hasten to correct it, by adding lime and raking it. In two hours time more lime is to be put in, and the vat raked again ; and these operations are to be repeated till it is recovered : but care must be taken not to run into the opposite excess.

It appears, that nothing requires so much attention in the management of a pastel vat, as the distribution of the lime. In considering this vat alone, it would be difficult to determine what passes in it : but the experiments related when treating of indigo, shew, that to render that substance soluble by lime or alkalis, it must be deprived of the oxygen it contains. The pastel in which putrefaction has commenced, and which is much disposed to run into the true putrid state, acts in two ways : it seizes

the oxygen of which the indigo is to be deprived, and at the same time affords a blue colouring matter analogous to indigo. But the putrefaction of this drug would take place with too much rapidity, if it were not restrained by the lime, which, as Pringle's experiments shew, has the property of resisting putrefaction. A principle use of the lime then, is to moderate the disposition of the pastel to putrefy, and to confine it to a state of gentle fermentation, sufficient to deprive the indigo of its oxygen, and to produce in the colouring matter of the pastel that slight combustion which it must undergo, to acquire properties analogous to those of indigo. Another use of the lime, or of one part of it, is to dissolve the blue particles which are rendered soluble. If too much lime be put into the vat, the necessary fermentation is stopped, and it must be renewed, either by heat, or by fermentable substances, or by absorbing the excess of lime by vegetable acids. If on the other hand, too little lime be put in, the pastel runs into a true putrefaction, which would destroy the indigo, and which must be brought back to a due degree of fermentation, by repeatedly adding lime till it is reduced to the proper point.

Two hours before dyeing, the vat is raked, and to prevent the sediment, called *paste*, (*patée*) from occasioning inequalities in the colour, a kind of lattice formed of large cords, termed a *cross* (*champagne*) is introduced, and indeed when wool is to be dyed in the fleece; a net with small meshes is placed over this. The wool or cloth being thoroughly wetted with clear water a little warm, is pressed out, and dipped into the vat, where it is moved about a larger or shorter time, according as the colour is required to be more or less deep, taking it out occasionally to air. The action of the air is necessary to change the green colour given by the bath to a blue. In a rich bath it is difficult to give an uniform colour to light blues: the best method of obtaining such shades, therefore, is to use vats already exhausted, and which begin to grow cold.

Wool and cloth dyed blue ought to be washed with great care, to carry off the particles not fixed in the wool; and those which are of a somewhat deep blue ought even to be carefully cleansed by fulling with soap, which does not alter the colour. Those designed to be dyed black ought to be treated in the same manner; but it is not so necessary for those intended to be green.

A vat containing neither pastel nor woad is called an *indigo vat* (*cuve d'Inde*). The vessel used for this preparation ^b is a copper, which, being of a conical figure, leaves between it and the brick-work that surrounds it, and on which its brim rests, an empty space sufficient for containing the fire. Into this copper are poured forty buckets of water, more or less, according to its capacity, in which have been boiled six pounds of *cendres gravelées*, twelve ounces of madder, and six pounds of bran. This liquor is to be put into the vat, grounds and all. Six pounds of indigo ground in water are then to be put in, and after raking it carefully, the vat is to be covered. A slow fire is to be kept up round it. Twelve hours after it is filled, it is to be raked a second time; and so on every twelve hours, till it is come to or become blue, which it will be in forty-eight hours. If the bath be well managed, it will be of a fine green, covered with coppery scales, and a blue scum or flower.

The theory of this vat is the same as that of the foregoing, except that the indigo is here dissolved by means of alkali instead of

^b Mémoire sur l'indigo, par M M. d'Orval & Ribaucourt.

lime. When this vat, which is much more easily managed than that of pastel, is in a proper state, it may be used for dyeing in the same manner as the preceding.

Hellot describes two vats in which the indigo is dissolved by means of urine. Madder is added to it, and in the one vinegar, in the other alum and tartar, of each a weight equal to that of the indigo. The quantity of urine ought to be very considerable. There is a probability, that the indigo, deprived of its oxygen by the urine and madder in fermentation, is dissolved by the ammoniac, which is formed in the urine, either by the action of heat, or by putrefaction. Hellot remarks, that an effervescence takes place on pouring in the solution of alum and tartar, which probably tends to stop the putrefaction. These vats are by no means comparable with that of pastel, or that of indigo before described, much less work being expedited by them, so that they are adapted only to small dye-houses.

For dyeing silk blue, the indigo vat before described is used. In general a larger proportion of indigo is put in, than is there directed, but nearly the same quantities of bran and

madder. Macquer says †, that if half a pound of madder be employed, for every pound of *cendres gravelées*, the vat becomes greener, and its colour is more fixed in the filk, without being of a less pleasing cast. The pastel vat, and the others that have been described, are not proper for dyeing filk, because they do not colour it with sufficient readiness.

When the vat is come to (*en état*) what is called a *brevet* is given it, with about two pounds of *cendres gravelées*, and three or four ounces of madder: it is then raked; and in four hours is ready for dyeing. The heat ought to be at that time moderated so that the hand may be held in it without pain.

Previous to its being dipped in this vat, the filk must be boiled with soap, in the proportion of thirty pounds of soap to a hundred of filk, and well cleansed from it by two or more beetlings in a stream of water. As the filk is very liable to take an uneven colour, it is necessary to dye it in small portions. Thus the workman dips each hank one after another, having first put it on a wooden cylinder; and when he has turned it once or oftener in the bath, he wrings it strongly over it, and airs it,

to turn the green colour to a blue. When the green appears thoroughly changed, he throws it into some clear water, after which he wrings it several times with the pin.

Care must be taken, that the silk dyed blue, dry speedily. In the winter, and in damp weather, it should be dried in a chamber heated by a stove, being hung on a kind of frame kept constantly in motion.

When the bath grows weak, and the green colour diminishes, a brevet is given it, into which are put a pound of *cendres gravelées*, an ounce of madder, and a handful of bran, well washed. When the indigo is exhausted, more of that also must be put in, with the due proportions of *cendres gravelées*, madder, and bran.

Some dyers use vats that are grown weak to dye light shades: but the blue then obtained is less beautiful, and less permanent, than when fresh vats containing a smaller quantity of indigo are employed.

Indigo alone is incapable of giving silk a deep blue: hence, when this is required, it is necessary to prepare it, by giving it another colour, or ground. For the *Turkey* blue, which is the deepest, a very strong archil bath is first given, and for the royal blue (*blue de roi*), one
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of the same kind, but weaker. Other blues are dyed without any ground.

There is a blue made, as deep as the royal blue, for the ground of which cochineal is used instead of archil, in order to render it more permanent, whence it is called *bleu fin*.

A blue of little durability is given to silk by means of verdegris and logwood: but it might be made more lasting, by first giving it a lighter shade than is intended, in a bath of this kind, afterwards dipping it in an archil bath, and lastly in the vat.

To dye raw silk blue, that should be chosen which is naturally white. It should be thoroughly soaked in water, and afterwards put into the vat in separate hanks, in the same manner as the scoured (*cuile*) silk. In general raw silk takes the dye more readily, and, if it be possible, the scoured silk is put into the vat before it. If raw silk require archil, or the other ingredients above-mentioned, it is to be treated in the manner above described.

According to Mr. Pileur d'Apligny, the vat for dyeing linen and cotton is a cask of about a hundred and twenty gallons. The quantity of indigo used is generally from six to eight pounds.

pounds. This indigo, after being pounded, is boiled in a ley drawn off clear from a quantity of lime equal to the indigo, and double its weight of pot-ash. The boiling is continued till the indigo is thoroughly penetrated by the ley, carefully stirring it all the while, that the indigo may not stick to the bottom of the vessel and burn.

Whilst the indigo is boiling, an equal weight of quick-lime is to be flacked. About twenty quarts of warm water are added, and in this is dissolved as much vitriol or sulphat of iron as amounts to twice the weight of the lime. When the solution is completed, the liquor is to be poured into the vat, which must be previously half filled with water. To this the solution of the indigo must be added, with the remainder of the ley which was not used in boiling it. When all these are put into the vat, it is to be filled up to within two or three fingers of the brim, and stirred with the rake two or three times a day, till it is in a state fit for dyeing, which it will be in eight and forty hours, and frequently sooner, according to the temperature of the atmosphere, on which, the time required to make this vat depends.

Some add to a vat composed nearly in the same manner as the foregoing, a little bran, madder, and pastel ^d.

At Rouen a more simple process is followed, which Mr. Quatremere thus describes.

The vats are constructed of a kind of flint, covered within and without with a coating of fine cement. In every dye-house there is a certain number, arranged in one or more parallel lines. Each vat is capable of containing four hogheads of water, and into it may be put eighteen or twenty pounds of indigo. The indigo having been macerated for a week in a caustic ley sufficiently strong to bear an egg, and then ground in a mill, in which not unfrequently the maceration is made, about three hogheads and a half of water are put into the vat, and afterwards twenty pounds of lime. When the lime is thoroughly slacked, the vat is raked, and six and thirty pounds of sulphat of iron or english copperas are put in. When the solution is completed, the ground indigo is poured in through a sieve. On that day it is raked seven or eight times: and, after hav-

^d Procès-verbal des opérations de teint faites à Yvetot par François Gonin.

ing stood at rest six and thirty hours, it is fit for dyeing.

It is necessary to have vats set at different times. The cotton, or thread, is first dipped in that which is most exhausted, going on from vat to vat, till it comes to the strongest, unless it have before attained the proper shade. It should be wetted before it is put into the first vat, and should not be left in the bath more than five or six minutes, as in that time it will have acquired nearly all the blue it can take up.

As soon as the dyeing in one vat is over, it should be raked, and not used again, till it has stood at least four and twenty hours unless it be newly set, when it need not stand quite so long.

When a vat has been dyed in three or four times, it begins to change: no more veins are seen on its surface after raking it, or it grows black. It is then necessary to *replenish* (*renourrir*) it, and for that purpose four pounds of sulphat of iron, with two of quick-lime, are added, and it is raked twice. A vat may be replenished three or four times, diminishing the ingredients in proportion as it falls off in strength and quality.

This

This vat may be rendered still more simple. It may be composed, as directed by Bergman, in the following proportions. Take three drams of indigo powdered, three drams of sulphat of iron, six drams of lime, and two pints of water. Rake it well, and in a few hours the vat will be ready for dyeing.

Mr. Hauffman describes a vat differing from the foregoing, only in the proportions of the ingredients. In it the indigo is in much smaller quantity. For three thousand pounds of water he takes thirty-six pounds of quick-lime, which he slacks in two hundred pounds of water: with this he mixes the indigo well ground: thirty pounds of sulphat of iron, perfectly free from copper, he dissolves in a hundred and twenty pounds of hot water: having left the whole at rest for a quarter of an hour, he finishes the filling of the vat, gently stirring it without intermission. He very justly observes, that the blue vat may be made with fine or common indigo at discretion, nothing more being necessary than to vary the quantity. From twelve to twenty pounds may be taken for the quantity of water above directed: nay somewhat more, if a colour like that of indigo in substance be required, particularly when it is
for

for dyeing linen. The shade depends greatly too, on the time the goods are left in the vat, and the times it has been used. It is easy, however, to obtain always the same shade nearly: nothing more being necessary for that purpose, than to add, from time to time, a certain quantity of a solution of indigo, prepared with the least water possible.

When this vat begins to grow turbid, dyeing in it must be discontinued. It must then be stirred, and left till the liquor above the sediment becomes clear. When the operation of dyeing in it is interrupted, it must be stirred a few times a week.

If the lime fail, from being saturated with carbonic acid, more must be added, after being slacked in a proper quantity of water. If the iron be too much oxydated to act on the indigo, sulphat of iron is to be added, always taking care, that there be more lime than is necessary to saturate the sulphuric acid; for it must not be forgotten, that a certain portion is wanted to dissolve the indigo.

When the indigo is exhausted, it suffices to add a fresh portion ground in water, to stir the vat a few times, and to let it settle; after which it is fit for dyeing afresh. With these precautions, Mr. Hauffman preserved the same vat
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for two years: and it might have been used much longer, if the accumulation of sediment had not been so great as to render it impracticable to dip any thing in it sufficiently deep.

Mr. Hauffman found, that a pattern of cotton cloth, dipped into water acidulated with sulphuric acid after it was taken out of this vat, acquired a blue more intense than a similar pattern left exposed to the air, or another put into river water.

Bergman mentions another vat, very convenient and expeditious for dyeing thread or cotton, which is thus described by Scheffer *. To very strong soap-boiler's ley indigo well powdered is added; in the proportion of three drams to a quart. After a few minutes, when the colouring feculæ are well penetrated by the ley, six drams of powdered orpiment are added. The bath is to be well raked, and in a few minutes it becomes green, and exhibits the blue flower with a pellicle at top, when the fire is to be put out, and the dyeing to commence.

* This vat does not differ from the preparation employed for printing cottons, which is called *bleu d'application*, except in the propor-

* Essai sur l'art de la teinture.

tions of orpiment and indigo, which are much greater in the latter, particularly the indigo. For this preparation, according to Mr. Hauffman, thirty pounds of pot-ash, twelve of quicklime, twelve of orpiment, and sixteen of indigo, to a hundred quarts of water, are taken; and it is thickened with gum, that it may be applied with a pencil, or a stamp. Mr. Oberkampff, all whose processes have been improved with great care, uses a still greater proportion of indigo. In Bergman's process, the indigo is scarcely an eightieth part of the water: in that of Scheffer still less: a twelfth in that of Mr. Hauffman: and an eighth in Mr. Oberkampff's. The proportions of the other ingredients in these processes also vary. Apparently these preparations would succeed on a scale in which the proportions should be greatly augmented, and there would be no difficulty in determining which would best attain the object proposed.

C H A P. IV.

Of Saxon Blue.

THE colour dyed by means of a solution of indigo in sulphuric or vitriolic acid has received the appellation of *saxon blue*, from having been discovered at Groffenhayn in Saxony, by counsellor Barth, about the year 1740. This discovery was kept secret for a time, but by degrees it got abroad. At first the solution was not made with indigo alone; but alumine, antimony, and other mineral substances were previously digested in the sulphuric acid, the indigo was added afterwards, and when the solution was finished, it was employed for dyeing.

Bergman made many experiments on this process, and he thinks, that if it has hitherto afforded only a fading colour, it has been because the acid used was too weak.

He puts, as has been already said, one part of indigo finely powdered into eight parts of sulphuric or vitriolic acid, so concentrated, that its specific gravity is to that of distilled water as 1900 to 1000. The mixture being made
in

in a glass vessel slightly stopped, a great heat is excited. After a digestion of twenty-four hours, in a heat of 30 degrees or 40 degrees (100 or 122 Farh.) the indigo is dissolved, but the mixture is quite opaque and black: by the addition of water it is rendered clear, and affords successively the various shades of blue, according to the quantity of water added. In a great number of experiments described by that illustrious chemist, he kept the stuff to be dyed twenty-four hours in boiling water, and then put a given weight into the bath more or less strong, till the colour of the bath was exhausted. From these experiments it appeared, that one part of indigo would in this way produce a deep blue on two hundred and sixty parts of stuff, which appeared to be then saturated, and incapable of taking up more indigo, at least so as to be fixed in it: that the cold bath acts equally with the hot: that the operation may be performed without waste of indigo; for the bath may be totally exhausted of its colour; and if it had too much, stuff not saturated may be added, by which all that remains will be absorbed: and that the bath, if saturated with salt of soda, gives only a very pale colour, if with sulphat of soda, a light blue,

blue, though much less weak; so that these salts are more or less injurious to the dye.

Similar experiments were made on silk, soaked in like manner in boiling water, and taken out of the bath after the space of a hundred and forty-four hours. The indigo solution gave a blue to the silk, as well as to the stuff, but the attraction by which the former precipitates the blue particles is more weak. The patterns of silk resisted the action of water alone very well, but they could not bear that of soap.

Thread and cotton took only very pale shades from this dye.

The deepest shades obtained by this process, when concentrated sulphuric acid is employed, suffer no change, as Bergman assures us. He says, that having exposed all the patterns to the sun for two months, the deep blues (such as are known with us by the name of Coventry blues) *bleus pers & turquins*, were scarcely weakened; but that the light shades suffered much more, becoming dull and greenish.

Mr. Quatremere says, that, among several dye-houses, he found only two, in which it was known how to make the dye of indigo with sulphuric acid penetrate into the internal part
of

of the stuff, when the colour is said to pierce or *cut* (*percer on trancher*): and that he gave it this property, by introducing fixed alkali, one ounce to an ounce of indigo and six ounces of sulphuric acid. With this preparation he dyed a pattern of a most deep and vivid blue, and the cut was as deeply tinged as the surface.

Mr. Poerner, who has paid great attention to this preparation, adopts the addition of alkali^a. He says, that by means of it, the colour is rendered more pleasing, and penetrates deeper. He directs only four parts of sulphuric acid to one of indigo. In the process described by him, four parts of concentrated sulphuric acid are poured on one of indigo reduced to a fine powder: the mixture is stirred for some time: after having stood twenty-four hours, one part of good dry pot-ash in fine powder is added: the whole is again well stirred, and, having stood twenty-four hours longer, more or less water is added gradually.

The same author says, that he has discovered a preparation of indigo in a dry form, which is more advantageous, more easy to be used, and more convenient than the preceding, but that he cannot yet communicate it to the public.

^a Instruction sur l'art de la teinture, &c.

To dye faxon blue, the cloth is prepared with alum and tartar. A greater or less proportion of the solution of indigo is to be put into the bath, according as the shade required is deep or light. In the dye-house this solution is called *composition*, and the colour obtained by it frequently *prussian blue*. The light shades may be dyed after the deep ones: but they have more lustre when dyed in a fresh bath. For deep shades it is best to put in the solution of indigo in different portions, raising the cloth on the winch.

. When I come to treat of green in the sixth section, I shall give a further account of this dye, and of the *english blue*, which is a variation of it.

C H A P. V.

Of Dyeing Blue by Means of Prussian Blue.

AS prussian blue furnishes the painter with a beautiful and permanent colour, attempts have been made to employ it in dyeing. Macquer, after having made many important obser-

observations on that substance, has endeavoured to render it useful in this art ^a.

I shall not stop to describe the properties of prussian blue, which have exercised the sagacity of many chemists, particularly of Macquer and Scheele: I shall only endeavour to give a sufficient idea of it. It is then, a combination of iron with a peculiar acid, which acid is formed by calcining animal substances with alkali, and which is distinguished by the name of prussic, whence its compounds are called prussiates. The prussiat of iron retains a little alkali, and from the nature of the compound, the iron in it is but little oxydated, so that it retains the black colour proper to it in that state. This colour a little modified is probably the principle of the colour of prussian blue, conformably to the principles established in the former part of this work.

Alkali, when digested on prussian blue, or prussiat of iron, takes from the iron the prussic acid; and if in this state of combination, it be mixed with a solution of iron, an exchange takes place, the alkali uniting with the acid which held the iron in solution, and the iron combining with the prussic acid. But when

^a Mém. de l'acad. 1749.

the alkali takes the prussic acid from the iron, it at the same time dissolves a portion of the metal; and when the iron resumes the prussic acid, it retains a portion of the alkali: so that both the prussiat of alkali, and the prussiat of iron, ought to be considered as triple compounds^b.

Macquer's first attempt was to soak thread, cotton, wool, and silk, in a solution of alum and sulphat of iron; then in an alkaline solution partly saturated with prussic acid; and next in water acidulated with sulphuric acid, which was to dissolve that part of the oxyd of iron not combined with the prussic acid, which the alkali not combined with that acid had precipitated. Repeating successively these immersions, he obtained a fine blue, but very unequal: and the wool and silk were become harsh to the touch, from the action of the alkali, and of the sulphuric acid.

It is easy to perceive, that this process could not succeed. For as an alkali not saturated with prussic acid was used in the second immersion, that part of the alkali which was not saturated must dissolve more or less of the blue taken up in the first. If any one, therefore,

^b Mém. de l'acad. 1786.

would repeat these experiments, he should employ an alkali saturated with prussic acid ; or perhaps lime-water, or rather magnesia, both of which have the property of combining with that acid.

In a second process, that learned chemist boiled his patterns in a solution of alum and tartar, and afterwards passed them through a bath in which prussian blue was mechanically diffused. They were now dyed evenly and soft to the touch ; but the colour was faint, and it was impossible to render it deeper.

Abbé Menon proposes another process for thread and cotton. It consists in first dyeing them black : then soaking them a few minutes in a solution of prussiat of alkali : and afterwards boiling them in a solution of alum, in which they acquire a very deep blue. If a lighter blue be required, they must be passed through a weak acid. This process is curious : in it the prussic acid appears to take the place of the astringent principle.

Many trials have been made to turn these experiments to advantage, particularly the first : but whatever care has been taken, the colour was frequently weak, dull, and uneven. They seem therefore, to have been renounced, and the only one now used has considerable analogy to

to the second of Macquer. In this the prussian blue is merely diluted by means of muriatic acid, which does not form with it a true solution, but attenuates it sufficiently to make it penetrate more copiously into cotton stuffs^c. I shall quote literally the description given of it by Mr. Roland de la Platiere, which agrees with the practice of certain dyers.

On fine prussian blue, in the proportion of a pound to a piece of stuff, powdered and passed through a very fine sieve, pour, in a vessel of delft ware, as much marine acid as will reduce it to the consistence of a syrup. Stir it continually whilst it ferments for about half an hour. Dilute it well, and stir it every hour for a day, till no more fermentation is perceptible, the particles are extremely divided, and intimately united with the acid.

In a trough narrower than the common ones, but widening more toward the top, being two feet and a half high, two feet and a half diameter at top, and two feet at bottom, put seven or eight buckets of water for one piece of velvet. To these add the composition, well diluted with water in a separate vessel, and poured into the bath through a very fine sieve. As

^c L'Art du fabricant de velours de coton.

soon as the piece is placed on the winch over the trough, stir the bath very briskly, and let down the piece speedily, working as fast as possible for one, two, or three hours ; passing the piece successively from the winch to the horse or board (planche) and from the board to the winch.

As the prussian blue is not really dissolved, but only very minutely divided, and is weighty, it is quickly deposited on the stuff, and always in greatest quantity on the first that presents itself. Hence it follows, that the colour is at first wavy and frequently in patches, whatever care be taken. At this we should not be surprised, though we ought to avoid it as much as possible ; work and rework the stuff ; wash the parts that have taken too much colour with the bath itself ; work it over again, now one end first, then the other ; dry it ; work it again, always as evenly and speedily as possible ; dry it once more, if necessary, and work it again, till we attain the proper shade, and the colour be perfectly even. There is no colour that requires a more experienced workman than this. The stuff is always to be washed and beetled between the dryings. In all kinds of baths it is necessary, that the stuff be put in thoroughly wet : if dry, the colour will not penetrate,

penetrate it without great difficulty, and always very unequally. The last time it is not washed, and is dried on the tenters (raime) in the open air, either in the sun or in the shade, provided the piece be well stretched.

• This colour, one of the most beautiful produced by art, is not changed by the air, though exposed to all its vicissitudes. Mr. Roland de la Patiere left patterns of it in the open air for six months together: for a long time the colour heightened (*a remonté*) and at last had lost but little. Acids are not injurious to it: boiling with alum even produces in it but little alteration. Dust, however, and rubbing on the creases of it, soon tarnish it; and the least touch of an alkaline liquor decomposes it instantly.

Instead of the muriatic acid, Mr. Guliche uses a solution of tin in nitro-muriatic acid for this operation.

Formerly a kind of sea green (*eccladon*) was made with sulphat of copper; but this colour, which approaches very near to blue, possesses no durability, and is no longer in use; I shall however, mention the processes for it. The cloth after having been fulled and moistened with warm water, was left for an hour in strong soap-suds, after which it was kept half an hour

or

or three quarters of an hour, in a solution of sulphat of copper or blue vitriol ; a net was employed to prevent the cloth from being rendered dull by the sediment from the soap and sulphat of copper ; sometimes in order to produce a more distinct green, a solution of copper was mixed with a bath of weld ; sometimes verdegris was substituted for sulphat of copper. Hellot describes a somewhat different process, by which the Dutch produced this colour in perfection. He says, that they mixed together equal parts of lime and sulphat of copper in a bag, and turned the cloth out of the copper with the soap-suds, into another that was contiguous, in which the particles of the copper that passed through the bag, gave it the green colour.

SECTION

SECTION III.

Of Red.

CHAPTER I.

Of Madder.

MADDER, a substance very extensively employed in dyeing, is the root of a plant which Linnæus divides into two species, the first, *rubia tinctorum foliis senis*, the second, *rubia peregrina foliis quaternis*. Of the first there are two varieties, the cultivated madder and the wild madder, called also *rubia sylvestris monspessulana major*.

Although madder will grow both in a stiff clayey soil and in sand, it succeeds better in a moderately rich, soft, and somewhat sandy soil, it is cultivated in many of our provinces, in Alsace, Normandy, and Provence, the best of European growth, is that which comes from Zealand.

There

There are various methods of cultivating and preparing madder, and many treatises have been written on the subject, that of Mr. Duhamel may be consulted, but more particularly that of Mr. le Pileur d'Apligny, published at the end of his art of dyeing threads and cotton stuffs.

The madder prepared for dyeing is distinguished into different sorts, that obtained from the principal roots is called *grape madder* (garance grape) the *non grape* is that which is produced from the stalks, which by being buried in the earth, are transformed into roots, and are called layers, *conchis*, each of these kinds is subdivided into robée, mi-robée, non robée, short or muil (mûle) *.

When the madder roots are gathered, the layers are separated from them, to form the non grape, and such of the fibres of the roots as do not exceed a certain degree of thickness are added, as are also those roots which are too thick, and which contain a great deal of heart or ligneous part : the best roots are about the thickness of a goose quill, or at most of one's little finger ; they are semi-transparent

* For an explanation of these terms, vide page 113.

and of a reddish colour, they have a strong smell, and the bark is smooth.

When the madder is gathered and picked, it must be dried, in order to render it fit for grinding and being preserved: in warm climates it is dried in the open air; in Holland, by means of stoves, which sometimes communicate too great a degree of heat, and change its colour by an admixture of fuliginous particles. Heliot ascribes the superiority of the madder which comes from the Levant, to the circumstance of its having been dried in the open air.

After the root has been dried, it must be shaken in a sack, or lightly beaten on a wooden hurdle, after which it must be sifted or winnowed. In this way the earth is separated from it, and the *billon* is removed, a name by which the small roots and their bark are distinguished. After this, nothing remains but to reduce it to powder, which may be done by a vertical millstone, or by pestles, or even by a common snuff mill.

All the parts of the madder cannot be powdered with equal facility; the outer bark and ligenous parts are more easily pounded than the parenchymatous parts. Advantage is taken of this circumstance in order to separate those parts,

parts, as they do not all give the same colour ; the outer bark as well as the wood within, afford a yellowish colour, which spoils the red we wish to obtain. This separation established the distinction of madder into robée, mi-robée, and courte. After the first operation of the mill, the madder is passed through a sieve with a cover fitted to it, by which means, what is called the short madder, which is intended for tan and mordoré colours is obtained ; the remainder is again ground and sifted, and thus the mi-robée is obtained ; and a third operation affords the robée. The madder thus powdered is to be preserved in a dry place, well packed in casks, where from its natural unctuousity it concretes into lumps.

Mr. Beckmann ^b agrees with Mr. Hellot in opinion, that the heat of stoves injures the colour of madder, and that it would be better to dry it in the air only, the effect of which might be promoted by various means. He finds that common ovens, immediately after the bread is taken out, may be used instead of the dutch stoves, when artificial heat is to be employed. Mr. d'Ambourney ^c has made

^b Nov. comment. societ. reg. Gotting. tom. viii.

^c Délibér. & mem. de la société d'agriculture de la généralité de Rouen.

some interesting experiments on madder; he thinks that the fresh root may be used in dyeing, with as much advantage as the powdered. He observed, that four pounds of the fresh are equal to one of the dried, although in the drying seven eighths of its weight are lost; the expence of stoving, packing, and sifting are saved, and it is only necessary to take care that the roots be thoroughly washed in a current of water, as soon as they are taken out of the ground; they are afterwards cut into pieces and bruised by the vertical mill. In dyeing with the fresh roots, on account of the quantity of water they contain, we must take care not to put too much water into the bath. Mr. Beckmann subscribes to Mr. d'Ambourney's opinion, though he has constantly made one observation which seems to contradict it; that madder is more fit for dyeing, after having been preserved for two or three years, than when fresh.

In the neighbourhood of Smyrna, and in the island of Cyprus, a kind of madder is cultivated, which affords a more lively red than that raised in Europe; on which account, it is employed in the preparation of the Adrianople red. In the countries where it grows it is called *chioeborza*, and *bazala*, but it is commonly

commonly known by the name *lizari*. It is now cultivated in Provence, and Mr. Beckmann has raised it with great success at Göttingen.

The red colouring matter of madder may be dissolved in alcohol, and on evaporation, a residuum of a deep red is left. Fixed alkali forms in this solution a violet, the sulphuric acid a fawn coloured, and the sulphat of potash a fine red precipitate. Precipitates of various shades may be obtained by alum, nitre, chalk, acetite of lead, and muriat of tin.

In macerating madder in several portions of cold water successively, the last receives only a fawn colour, which appears entirely different from the peculiar colouring particles of this substance, and resembles that which is extracted from woods and other roots; this fawn coloured substance perhaps, does not belong to the pulp, and is only found in the ligneous and cortical parts.

After having by repeated boiling exhausted the madder of the colouring parts that are soluble in water, it still retained a deep colour, and alkali extracted from it much colouring substance; the residuum which still remained coloured, was very inconsiderable, so that the pulp appears wholly composed of colouring
I 2 matter,

matter, a good part of which is not soluble in simple water.

Oxygenated muriatic acid employed in sufficient quantity to change an infusion of madder from a red to a yellow colour, produces a small quantity of a very pale yellow precipitate, and the supernatant liquor is transparent, retaining a greenish yellow colour more or less deep, according to the quantity and strength of the oxygenated muriatic acid.

The quantity of this liquor required to destroy the colour of a decoction of madder, is double what is necessary to destroy that of a decoction of an equal weight of brasil wood, which proves, that the colouring particles of madder are much better calculated to resist the influence of the air, than those of brasil wood, they would be easily changed however, if not rendered fixed by mordants. To this, I shall add some of the celebrated Mr. Watt's experiments, which he has been so kind as to communicate to me, and which he made with the best Zealand madder.

A. This madder is of a brownish orange colour, and of the consistence of a coarse powder possessing a slight degree of cohesion: it attracts moisture, in which case it loses its properties,

properties, so as to become unfit for the purposes of dyeing.

B. With water it affords an infusion of a brownish orange colour ; its colour cannot be extracted without a great deal of water, Margraff directs three quarts of water for two ounces of madder. Its colouring particles may be extracted either by hot or cold water ; to the latter it appears to give a more beautiful colour ; its decoction is brownish.

C. When an infusion or decoction of it is slowly evaporated in an open vessel, a pellicle is formed on the surface, which gradually falls to the bottom, after which fresh pellicles are successively formed until the evaporation is finished.

D. The extract thus prepared is of a dark brown, it partly dissolves in water, to which it communicates a lightish brown colour.

E. The infusion set to digest for some days in an open vessel, which should be of such a height, that the liquor reduced to the form of vapour, may fall back again, deposits dark brown pellicles, the liquor remains of a brownish colour, and the pellicles are soluble in water, but with difficulty.

F. Alum forms in the infusion B a deep brownish red precipitate composed of pellicles,

and the supernatant liquor is of a yellow colour inclining to brown.

G. Alkaline carbonats precipitate from this last liquor a lake of a blood red colour, which has greater or less intensity according to the quantity of alum that has been dissolved in it. In this way a blood red lake may be obtained; but we cannot by any means hitherto known, give it the brightness of cochineal lake; in oil it is transparent, but in water it is opaque and without beauty.

H. If a superabundant quantity of alkali be employed, the precipitate is redissolved, and the liquor becomes red.

I. The lake precipitated by pot-ash, is of a more beautiful colour than that by the mineral alkali.

K. Calcareous earth precipitates a more dark and brown coloured lake than alkalis, particularly if it forms lime water.

L. If a few drops of alkali are added to the water employed in making the infusion B, the infusion extracts many colouring particles of a deep red bordering on brown. 1st. Alum precipitates a deep brown lake from this infusion. 2dly. Acids added in small quantity change it to a yellowish colour, and in greater quantity render it a brown yellow, but they precipitate

precipitate nothing from it. 3dly. This infusion evaporated to dryness, forms a gummy extract; which easily dissolves in water.

M. If the infusion B is made with water very slightly acidulated with a mineral acid, it is yellowish. 1st. This liquor long digested becomes of a greenish brown, and the yellow appears to be destroyed. 2dly. The addition of an alkali restores the red colour, and the infusion then gives on evaporation an extract which readily dissolves in water.

N. If carbonat of magnesia be added to the water used for the infusion B, the infusion is of a clear blood red, and on evaporation forms a blood red extract, which readily dissolves in water. 1st. A solution of this extract which is employed as a red ink, when exposed to the light of the sun becomes yellow. 2dly. Alum precipitates from this infusion a small quantity of an ill-coloured lake. 3dly. Alkalis give it a redder and more fixed colour.

O. If the infusion be made with a solution of alum, it is of an orange yellow. 1st. This infusion precipitated by an alkali, gives a lake resembling that of F, but its colour is not so good.

P. A solution of acetite of lead added to the infusion B, forms a brownish red precipitate. 1st. A solution of mercury in the nitric acid gives a purple brown precipitate. 2dly. A solution of sulphat of iron, a fine bright brown precipitate. 3dly. A solution of sulphat of zinc has not been tried. 4thly. A solution of sulphat of manganese, a purple brown precipitate. 5thly. A solution of iron in the nitro muriatic acid has not been tried.

Q. The infusion B being mixed while hot with the infusion of cochineal, a brownish red precipitate bordering on a deep purple was formed, of difficult solubility in water; by continuing the digestion, a greater quantity of this precipitate appeared. 1st. A pattern soaked in a preparation which the linen printers use, having been dyed in this mixture, took a brownish red colour, and after having been boiled in a solution of soap, the colour appeared pretty good. 2dly. The solution of soap became very red, it communicated however a very indifferent colour to paper.

C H A P. II.

*Of the Processes employed in Dyeing with
Madder.*

WOOL would receive from madder, as has been already stated, only a perishable colour, if its colouring particles were not fixed by a base which occasions them to combine with the stuff more intimately, and which in some measure, defends them from the destructive influence of the air. For this purpose, the woollen stuffs are first boiled for two or three hours with alum and tartar, after which they are left to drain, they are then slightly wrung and put into a linen bag, and carried into a cool place, where they are suffered to remain for some days.

The quantities of alum and tartar as well as their proportions, vary much in different manufactories: Hellot recommends five ounces of alum and one ounce of tartar to each pound of wool; if the proportion of tartar be increased to a certain degree, instead of a red, a deep and durable cinnamon colour is produced, because as we have seen, acids have a tendency
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to give a yellow tinge to the colouring particles of madder. Mr. Poener somewhat diminishes the proportion of tartar, he directs that it should be only one seventh of the alum; Scheffer, on the contrary, directs that the quantity of tartar should be double that of the alum, but I have found that by employing one half tartar, the colour sensibly bordered more on the cinnamon, than when the proportion was only one fourth of the alum.

In dyeing with madder, the bath must not be permitted to boil, because that degree of heat would dissolve the fawn coloured particles which are less soluble than the red, and the colour would be different from that which we wish to obtain.

When the water is at a degree of heat which the hand can bear, Hellot directs us to throw in half a pound of the best grape madder for each pound of wool to be dyed, and to stir it well before the wool is put in, which must remain for an hour without boiling, but in order to be more certain of the dye, it may be boiled for four or five minutes towards the end of the operation. Mr. Beckmann advises the addition of a little alkali to the madder bath; I approve the plan in the dyeing of thread and cottons.

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By this process reds are obtained which are never so beautiful as those produced even by kermes, much less, those from lake and cochineal; but as they cost but little, they are used for common low priced stuffs. The madder reds are sometimes rosed with archil and brasil-wood, in order to render them more beautiful and more velvety, but the brightness given them in this way is not lasting.

The quantity of madder which Mr. Poerner employs is only one third of the weight of the wool, and Scheffer advises only one fourth. Mr. Poerner says, that having added to the alum and tartar, a quantity of solution of tin of equal weight with the tartar, and after two hours boiling, having let the cloth remain in the bath that had been left to cool for three or four days, he dyed it in the usual way, and obtained a pleasing red. He describes another process, in which, after having prepared the cloth by the common boiling, he dyed it in a bath but slightly heated with a larger quantity of madder, tartar, and solution of tin; he let the cloth remain twenty-four hours in the bath, and after it had become cold, he put it into another bath made with madder only, and there left it for twenty-four hours; in this way he obtained a pleasing red, somewhat clearer than
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the common red, and bordering a little on a yellow. According to Scheffer, by boiling wool with a solution of tin, the quantity of which he does not mention, with one fourth of alum, and by dyeing with one fourth of madder, an orange red is obtained.

Bergman says, that if without boiling the wool, it be dyed with one part of a solution of tin, and two parts of madder, it acquires a cherry colour, which when exposed to the air acquires a deeper tinge.

If wool be boiled for two hours with one fourth of sulphat of iron, then washed, and afterwards put into cold water with one fourth of madder and then boiled for an hour, a coffee colour is produced; Bergman adds, that if the wool has not been soaked, and if it be dyed with one part of sulphat of iron and two of madder, the brown obtained, borders upon a red.

According to these chemists, by employing sulphat of copper as a mordant, we obtain from madder a clear brown bordering on yellow. A colour of the same kind will be produced, by dyeing the wool simply soaked in hot water, with one part of sulphat of copper and two of madder; if equal parts of these two substances be used, the yellow will be somewhat more ob-

scure, bordering on a green; in both these cases, the colour does not become darker by exposure to the air.

I have employed a solution of tin in various ways, both in the preparation and in the madder-
dyeing of cloth. I have used different solutions of tin, and I have found, that the tint was always more yellow or fawn coloured, although sometimes brighter than that obtained by the common process.

Madder does not afford a colour sufficiently bright for dyeing silk; de la Folie, however, has given us a process for employing it for this purpose.

Half a pound of alum is to be dissolved in each quart of hot water, to which two ounces of pot-ash are to be added; after the effervescence has ceased, and the liquor has begun to grow clear, the silk must be soaked in it for two hours, it is then to be washed and put into a madder bath; silk dyed in this way becomes more beautiful by the soap proof^a. Scheffer gives us a somewhat different process; the silk is to be alumed in a solution of four ounces of alum with six drams of chalk for each pound of scoured silk; when a sediment

^a Journal de Physique, t. xiii. p. 66.

is formed, the solution is to be decanted, and after having become quite cold, the filk is to be put into it, and to be left eighteen hours; it is then to be taken out and dried, after which it is to be dyed with an equal weight of madder, when it takes a pretty good, but rather dark red. Mr. Guliche also describes a process for dyeing filk with madder^b; for one pound of filk he orders a bath of four ounces of alum and one ounce of a solution of tin; the liquor is to be left to settle, when it is to be decanted, and the filk carefully soaked in it, and left for twelve hours, and after this preparation, it is to be immersed in a bath containing half a pound of madder softened by boiling with an infusion of galls in white wine; this bath is to be kept moderately hot for an hour, after which it is to be made to boil for two minutes. When taken from the bath, the filk is to be washed in a stream of water and dried in the sun. Mr. Guliche compares the colour thus obtained, which is very permanent, to the turkey red. If the galls are left out, the colour is clearer. A great degree of brightness may be communicated to the first of these, by afterwards passing it through a bath of brasil wood

^b Vollständiges farbe, &c. iv band.

to which one ounce of solution of tin has been added, the colour thus obtained, he says, is very beautiful and durable.

Madder is used for dyeing linen and cotton red, and even for giving them many other colours by means of different admixtures; it is the most useful of all the colouring substances employed in this kind of dyeing. It is proper to enter into a somewhat minute detail of the different means by which this kind of dye may be rendered more certain, more beautiful and varied. Thread does not so easily take a colour from madder as cotton, but the processes which succeed best for the one are also to be preferred for the other.

The madder red of cotton is distinguished into two kinds, the one is called simple madder red, the other, which is much brighter, is called Turkey or Adrianople red, because it comes from the Levant, and has seldom been equalled in brightness or durability by our artists.

Madder reds likewise differ very much in brightness and permanency according to the processes employed. We are indebted to Mr. Vogler for some very interesting experiments on this subject, of which I shall now give a summary account. Mr. Vogler first considers
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the mordants, and afterwards the preparation of the madder bath.*

The first mordant he tried, consisted of a solution of three drams of roman alum in fourteen ounces of water. Thread and cottons boiled for some minutes in this solution, and afterwards passed through the different madder baths, which will be hereafter described, took a slight poppy-coloured red. Our author observed in this, and many other experiments, that roman alum was much better than common alum, and gave greater brightness to the colours. He always used yellowish thread and cotton, which he first leyed, then washed and dried.

The above proportion of alum appeared to him the best, yet though he repeated the aluming three times, he was not able to give the thread and cotton a good colour. The addition of the smallest quantity of any kind of acid rendered it paler; the addition of arsenic produced no effect; sheep and cow dung, and album grecum, added to the mordant, as also urine employed instead of water to dissolve the alum, contributed somewhat, but not much,

* Crell neueste entdeckungen, vol. xiii. An. de Chym. t. iv.

to strengthen the colour. Muriat of soda and ammoniacal muriat had more effect, but these salts rendered the colour more dull; lime-water acted very much in the same way. The substances which had the best effect were gum arabic, starch, fenugreek-feed, and above all, glue. The author says he has attempted to impregnate thread and cotton with fish oil, hogs-lard, and olive oil, but without success. The gastric juice and the ferous part of the blood of animals act like the glue.

The thread and cotton may be soaked alternately in a solution of glue and a solution of alum, or the glue may be dissolved with the alum, in the proportion of from one dram and a half to four drams, with the quantity of alum directed. It is necessary to choose fine glue. This substance used with alum produces a more saturated colour, but without alum the red is dusky.

Muriat and nitrat of alumine not only produce a more intense and durable red than alum, but the tint is pleasanter, more especially when the nitrat is employed. In general, muriats render the colour darker, more saturated, and more durable. Corrosive mercurial muriat produces the same effect.

Having dissolved in a strong ley of pot-ash, as much powdered white arsenic as it would take up with the assistance of heat, and having mixed this solution, which had been diluted with two parts of water, with a saturated solution of alum, the mixture became turbid and of the consistence of jelly; it recovered its transparency on adding gradually a solution of alum.

Thread and cotton soaked for twelve hours in this mordant, when washed and dried received from madder a beautiful well saturated colour. Thread and cotton which had been for six hours in nitro-muriatic acid, and afterwards washed and dried, took from madder a more beautiful and durable colour, than that which dyers obtain from annotta; some bad madder by means of this mordant afforded a yellowish brown of an agreeable shade.

This colour may be changed into a poppy-coloured red, which may vie with the most beautiful colours of this hue obtained from brazil wood and cochineal, by first soaking the stuff in a solution of alum and common salt, and boiling it a second time with madder.

Mr. Vogler macerated for a night three drams of pot-ash with an equal quantity of common

mon madder in a pound of water, he then applied a boiling heat, and put into it some thread and some cotton, and after half a quarter of an hour's boiling, he took it out, rinsed and dried it, then soaked it in a solution of alum and common salt, after which he passed it through a solution of glue, and at last dipped it in a madder bath; it took a fine full red.

If to the preparation of madder and pot-ash annotta be added, the thread and cotton take in this bath a beautiful orange colour; it is thus that the dyers in many places prepare that colour, but it is not so durable as that above described.

If instead of pot-ash roman alum be employed, a colour is obtained which is at first weak though more lively than with the pot-ash, and on going on with the process a fine full red is obtained.

By giving a weak madder colour to thread and cotton that have been alumed, by afterwards soaking them in a solution of alum and salt, impregnating them with glue, and dyeing them a second time in a madder bath, they take a beautiful very lively red.

The red of thread and cotton coloured by two madderings was very much weakened by the nitric, sulphuric, and muriatic acids, diluted

ted with two parts of water, and became more or less pale and yellow. The action of the nitric acid was the most powerful, and that of the muriatic the weakest; this last turned the colour brown. The vegetable acids have a much weaker action; a solution of alum powerfully dissolved the colour, rendered it clearer, and at the same time brighter; potash and lime water have the property of extracting much of its colour, and changing it to a deep red.

Galls dispose thread and cotton to receive the madder colour. Mr. Vogler's preparation for galling consisted of five drams of black galls, kept for twenty-four hours in a pound of water, which was then boiled for ten minutes, and sometimes he added six drams of common salt. The galled thread and cotton after having received the mordants of alum and salt, took with the madder, a perfectly saturated colour but which was of a dark red. Thread and cotton successively impregnated with a solution of tin and glue, steeped in an infusion of cochineal and galls, washed and dried, and afterwards impregnated with the alum and salt mordant, and last of all dyed in a madder bath, received an uncommonly beautiful colour which was very bright and considerably durable.

durable. The mordant of alum and corrosive muriatic of mercury and that of alum and salt gave a somewhat deeper colour.

Mr. Vogler was equally successful, when instead of galls he used several other vegetable astringents, such as the ground bark of the alder and oak, the powdered bark of walnut-tree root, flowers and bark of pomegranate, the leaves, bark, and tops of the sumach. He made many experiments with metallic and earthy salts, all of which except the aluminous and the solution of tin, appeared to him to be but little adapted or entirely hurtful in the dyeing of red: we shall communicate the principal results.

The solution of nitrate of lead employed as a mordant, produced a very loaded dirty red inclining to brown. In general, solutions of lead used as mordants for thread and cotton dispose them abundantly to receive colours from all vegetable colouring substances, but they have always a dark and dirty appearance. These mordants may be employed for brown or black colours; the bad brown just mentioned for instance will change to a perfect brown of a very beautiful shade, if passed through a mordant of alum and salt, and boiled a second time with madder. Mr. Vogler obtained a very fine

black, by galling thread and cotton impregnated with salt of lead, and then putting them into a solution of sulphat of copper, and boiling them in a bath of logwood.

Cobalt dissolved in the nitro-muriatic acid produced a very pleasant colour nearly resembling a very saturated violet. A solution of sulphat of copper gave a bad lilac. Verdegris dissolved in vinegar produced the same effect.

The nitrat of copper produced a much more beautiful and saturated colour.

Thread and cotton that have received the mordant of sulphat of copper or iron, take in the madder bath a dirty dull violet colour.

Mr. Vogler having added the alkaline solution of arsenic above mentioned, to a moderately saturated solution of sulphat of copper or iron, produced a turbid mixture which effervesced, and he rendered it transparent by adding sulphat of iron. Thread and cotton impregnated with this preparation received a beautiful saturated puce colour which penetrated them deeply.

The nitrat and muriat of iron produced a better effect than the sulphat and acctite, they afforded a beautiful well saturated violet colour. The alkaline solution of arsenic mixed with earthy and metallic salts generally render
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them better mordants for all colours. This likewise renders the effect of the mordants into which it enters more lasting, so that the stuff impregnated with it many years before, may be dyed without disadvantage, a circumstance we do not remark respecting any other mordant, excepting a solution of tin. Sulphat of zinc afforded a weaker violet than sulphat of copper. Sulphat of lime and calcareous nitrat produced no effect. Sulphat of manganese discovered some though but little action. Mr. Vogler remarks, that it is necessary always to rinse the cotton and thread when they come out of a mordant ; if this precaution be neglected, a weak colour only is frequently obtained, where a strong one was expected, because the particles of the mordant dispersed through the bath, combine with the colouring particles and are precipitated with them ; this precaution is especially necessary, when we dye with substances which do not contain much colouring matter.

Mr. Vogler prepares the madder bath in different ways. He put three drams of madder into from sixteen to eighteen ounces of water, he macerated it for twenty-four hours, then boiled it for a quarter of an hour, introduced the thread and cotton, and boiled them for half

a quarter of an hour, he afterwards washed them in two or three waters, and then dried them in the shade ; he remarks that by long boiling, the colour of the stuff is taken away and destroyed.

Fresh urine substituted for water affords more lasting colours, but in summer it is apt very soon to become putrid, so as to render the infusion incapable of giving the dye.

One dram of sheep's dung or *album grecum* produced the same effect as the urine.

Three drams of muriat of soda or one dram of ammoniacal muriat produced a fuller but less bright colour. Sulphat of pot-ash and nitre had no effect.

Three drams of white sugar afforded a more beautiful and saturated colour ; on the addition of four drams of long pepper, it was found to have become more capable of resisting the nitric acid.

One dram or one and a half of starch or gum arabic thrown into the bath just as it begins to boil, and before the cotton is put in, gives a finer and more saturated colour ; one dram of fenugreek seed produced very nearly the same effect.

If in the beginning of the digestion four drams of spanish pepper are added, we obtain
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from the liquor colours that are more durable than the preceding, especially if we afterwards add three drams of common salt.

From one ounce to one ounce and a half of glue in the state of jelly thrown into the liquor as the ebullition commences, affords a particularly beautiful full colour, and the addition of three drams of common salt not only renders the colour more lasting, but preserves the infusion from becoming putrid.

The most beautiful colour of all, however, is obtained by mixing four drams of ox gall with the decoction, but at the same time it must be observed, that this colour is more easily destroyed by the nitric acid than any other.

All the madder baths except those prepared with urine, glue, and animal dung, may be preserved for a long time without losing their power. Mr. Vogler kept some till they became mouldy and foetid, and yet they dyed very well; nay he observes that they produced more durable colours, or at least, colours which resisted the action of the nitric acid more powerfully.

On putting from thirty-six to forty grains of crystals of tartar into the bath, just as the linen was thrown in, the colour produced, was found capable of resisting the nitric acid. The
sulphuric,

fulphuric, nitric, and muriatic acids, in very small quantity, produced the same effect; in too large a quantity they weakened the colour and rendered it pale. One dram and a half of powdered alum made the colour finer, but not more durable; twenty-four drams of corrosive muriatic of mercury, rendered it more obscure but more permanent. White arsenic employed in different proportions never occasioned the least change, though dyers frequently use it as well as orpiment, with a view of making the colour more durable.

In Mr. Vogler's experiments, cotton always took the colour better than thread, the difference however, was not very great, when he employed linen or hempen cloth that had been a little worn, and that had become soft to the touch, and when its texture was loose and the thread slightly twisted.

Mr. le Pileur d'Apligny gives a very minute description of the process employed at Rouen for dyeing cotton red; it is as follows:

The cotton must be scoured, galled with one part of galls to four of the cotton, after which it must be alumed with four ounces of roman alum to one pound of cotton, and an equal weight of water; to the solution of alum, one twentieth part of a solution of soda, consisting of

of half a pound of soda to a quart of water, must be added.

Some use only half the quantity of soda, and one sixth less of water, which they replace by a solution of tartar and arsenic. Mr. le Pileur d'Apligny thinks these last ingredients counteract each other. We have seen by Mr. Vogler's experiments that tartar used with the mordant weakens the colour, and that arsenic was only useful when combined with an alkali.

Others add acetite of lead or saccharum saturni, or muriat of tin. Mr. le Pileur d'Apligny advises the addition of some vinegar to the acetite of lead, in order to prevent the precipitation which is formed, when it is dissolved in water.

When the cotton is taken out of the mordant, it is slightly wrung with the pin, and dried; the colour is more beautiful as the drying is slow. They generally dye only twenty pounds of cotton at a time; it is better to dye even only ten, because when too great a number of hanks are wrought in the copper, it is much more difficult to dye them equally.

A copper in which ten pounds of cotton are to be dyed, should hold about two hundred and forty quarts of water, which must be heated:
when

when almost too hot for the hand, six pounds and a quarter of good dutch grape madder are to be added, and carefully dispersed through the bath. When it is well mixed with it, the cotton which has been previously put upon the sticks and placed on the edge of the copper, is to be immersed hank by hank. All the cotton being put into the bath, it is to be worked, the hanks on each of the sticks being turned for three quarters of an hour, and the bath kept constantly at the same degree of heat without boiling. At the expiration of this time, the cotton is taken out and placed on the edges of the copper, a pint of the above ley of soda is to be added to the bath, the cotton is then to be returned into the bath, and boiled from twelve to fifteen minutes, lastly, it is to be taken out and left to drain, wrung, washed in a stream of water, and wrung on the pin a second time.

Two days afterwards, the cotton receives a second maddering in the proportion of eight ounces to the pound, and is worked about as in the first maddering, with this difference, that no ley is added, and that well water is employed for the bath; this maddering being finished, the cotton is left to cool, washed, wrung, and dried.

Mr.

Mr. le Pileur d'Apligny does not think this method of dyeing by two baths a good one, because it requires more time and fuel, and because the second maddering cannot furnish much dye, the salts of the mordant having been exhausted by the first. He proposed another method, in which he says several dyers have already succeeded ; it consists in aluming the cotton twice, and then dyeing it by one bath only.

In order to render this red more lively, a quantity of warm water, sufficient to moisten the cotton, is put into a caldron or vat, into which about a pint of the ley is to be poured, the cotton is to be soaked in this bath, pound by pound, left there for a moment, taken out, wrung, and dried. According to Mr. le Pileur d'Apligny this operation is useless, for as the red cotton is intended for making stuffs, from whence it is necessary to separate the preparation when they are to be wrought, the colour of the cotton is at the same time rendered more lively, because it is passed through warm water rendered more active by the addition of a little ley. When the stuffs are taken out of this water, they are washed in a stream, and spread upon the grass, where the red brightens more than it would do by any other operation.

The

The red in printed stuffs is likewise produced by madder, but it must be fixed by a mordant. Mr. Wilson describes that which is used for this purpose, as follows, in four pounds of hot water (some employ lime water) three pounds of powdered alum, and one pound of saccharum saturni, or acetite of lead; are to be dissolved, this solution is put into a vessel sufficiently large to allow of the effervescence which takes place, and two ounces of powdered chalk, two ounces of pot-ash, and two ounces of corrosive muriatic of mercury, or corrosive sublimate, are to be added. This mixture must be well stirred and suffered to settle, the clear liquor must then be decanted, or what is better, filtered.

With this liquor, coloured with the decoction of brasil wood, they print, and pass the stuff through hot water, in which cows dung has been diffused, in order to take away the starch or gum, used to give consistence to the mordant, they then carefully wash it, and put it into a madder bath. All the stuff becomes coloured, but that which has not been fixed by the mordant is destroyed, by alternately boiling with bran and exposure on the grass.

Mr.

Mr. Oberkampf uses the same ingredients for the mordant, except that he does not put into it any corrosive mercurial muriat. We have seen by Mr. Vogler's experiments, that that metallic salt rendered the colour of the madder more durable, and at the same time deeper.

I shall here call to the reader's recollection that alum is decomposed by acetite of lead, and that there results from the decomposition an acetite of alumine, while the lead combined with the sulphuric acid, forms an insoluble salt, which remains in the sediment. The alkali and the chalk serve to take up the superabundant acid, which would weaken the colour of the madder, and give it a yellow tinge.

Mr. Wilson directs the use of this mordant, which is known by the name of printers mordant, and which is the same which Mr. Watt refers to in the experiments above mentioned, relative to the dyeing cotton red; according to his process it must be galled, dried, impregnated with the mordant, diluted with hot water, dried a second time, maddered, washed, and dried again.

The Adrianople red possesses a degree of brightness, which it is difficult for us to approach by any of the processes hitherto mentioned,

tioned, it has likewise the property of resisting much more powerfully the action of different reactives, such as alkalis, alum, soap, and acids. Mr. Vogler confesses that by his numerous processes, he has not been able to obtain a red of a degree of permanency equal to that of the Adrianople red, though he has much excelled in this respect the false Adrianople reds used for Siamese (*siamoisés*) and other red stuffs. It is necessary to remark, that soap suds weakens and destroys the most durable madder colours, even that of the Adrianople cotton; hence it appears, that we ought as much as possible to be sparing in the use of soap, in the washing of thread and cotton of this colour; the only difference between the true and false Adrianople red, is this, that the one resists these influences much longer than the other. Aqua fortis or dilute nitric acid, is according to Mr. Vogler the best and most expeditious test, for distinguishing the true Adrianople red from the false. If we immerse a thread of the latter dye in it, it soon becomes pale, and in less than a quarter of an hour white, while the true Adrianople red will remain in it for an hour without any alteration, and indeed never entirely loses its colour, which acquires an orange hue.

The

The Adrianople red, which for a long time came to us by our Levant trade only, excited the industry of our artists, but their attempts were for a long time fruitless, or their success confined to a very few manufactories. The Abbé Mazcas published some experiments which threw considerable light on this kind of dye, and government, from the information it received, published in 1765 an instruction under the title of *A memoir containing the process for dyeing spun cotton of the same scarlet red as that of the Adrianople cotton*. We find the same description in Mr. le Pileur d'Apligny's treatise, but the process has not succeeded completely: the fault seems principally to have consisted in making the alkaline solution too strong. The alterations made in different manufactories, with more or less success, have been kept secret. For the following description I am indebted to Mr. Clere, who has the management of a manufactory at Vaudreuil, and who has sent me a pattern of his cotton, which is dyed of a beautiful and durable red.

Process for the Adrianople or Turkey Red.

When a hundred pounds of cotton are to be dyed, we must begin by scouring it well. This operation consists in boiling the cotton in a ley of soda, marking one degree of the arcometer, to which is commonly added the remainder of the bath which has been employed for passing the cottons through, for *the white preparation* (en l'apprêt blanc) which is called *sickion*.

In order to scour the cotton properly, and prevent it from entangling, a cord is passed through three hanks (the hank is composed of four knots (pentes) each of which weighs a quarter of a pound, making the hank equal to a pound) and it is thrown into the ley when it begins to boil; it is carefully immersed, that it may not be scorched by the upper part of the caldron, which should contain about one hundred and fifty gallons of water for a hundred pounds of cotton: the cotton is completely scoured when it sinks of itself in the caldron; it is then taken out, and washed knot by knot in the river, wrung, and hung out to dry.

Second Operation ; Bath with Dung.

A hundred pounds of Alicant soda (barilla) in coarse powder, are put into a tub with a hole near its bottom, to allow the water to run into another tub placed under it ; seventy-five gallons of lixivial water are poured on the soda in the upper tub ; when the water which has run into the lower one marks two degrees of the soap-makers areometer, it is proper for the bath with dung, which is made in the following manner.

Twenty-five or thirty pounds of sheeps dung are mixed with the above ley in a large earthen vessel, and stirred with a wooden pestle, then passed through a hair sieve placed over the vat in which the bath is to be prepared, twelve pounds and a half of Provence olive oil are then poured into the vat, and kept constantly stirring with a rake, that it may be perfectly mixed with the ley and the dung ; the soda ley is poured upon it, nine buckets of water (each equal to four gallons) are commonly required for a hundred pounds of cotton. The bath being thus prepared is in a proper state to receive the cotton. For this purpose, some of the bath is taken in a wooden bowl, and poured into

an earthen pan set in brick-work at a proper height for working. A hank of cotton is taken and well wrought with the hands; it is frequently taken up and turned in the pan, and then hung upon a wooden hook fixed to the wall; it is slightly wrung out, and thrown upon a table, and the same operation is repeated with each hank. The table upon which the cotton is thrown ought to be raised eight or ten inches from the ground. A workman takes a hank in each hand, and strikes it on the table to stretch the threads; he turns it three times, and then makes a small twist to form a head for the hank and lays it upon the table: not more than three hanks should be placed one upon another, as too great a weight would squeeze the bath out of the under hanks. The cotton ought to remain ten or twelve hours on the table, and then be hung out to dry.

Third Operation; Bath with Oil, or White Bath.

Ley of soda also at two degrees of the areometer is taken, and after the vat in which the bath with dung was made has been well cleaned, twelve pounds and a half of olive oil are put into it, and the ley of soda added while it is kept constantly stirred with a rake, in order to
mix

mix the oil completely. This bath ought to resemble thick milk, and that it may be good, it is necessary that the oil should not rise to the surface; some of this bath is then put into the pan, and the cotton dipped hank by hank, as in the former operation; it is thrown on the table, and beat upon it, which is called *crêper*; it is left there till the next day and then hung out to dry. For this bath about eight buckets of ley are required.

Fourth Operation; first Salt.

Fresh soda is added to the remainder of that first put into the tub, if the water poured upon it has not attained three degrees. For this operation eight buckets of ley are poured into the vat upon the remains of the white bath, and the cotton is passed through it in the same manner as before. This operation is called *giving it the first salt* (*donner le premier sel*). The ley being at three degrees.

Fifth Operation; second Salt.

The cotton is passed through a ley of soda at four degrees, the working being conducted as before described.

Sixth Operation; third Salt.

The cotton is passed through a ley of soda at five degrees.

Seventh Operation; fourth Salt.

The cotton is passed through a ley of soda at six degrees, the same precautions being observed, and then carried out to be dried on very smooth poles; when dry, it is taken to the river to be washed in the following manner.

Eighth Operation.

The cotton must be first soaked in the water, then taken out and put upon the horse (bayard) to drain; water is repeatedly thrown on it, that it may be well soaked, and an hour after it is washed knot by knot, to free it completely from the oil, which is absolutely necessary to its taking the galling well; it is then wrung with the jack and pin, and stretched upon the poles to dry: the cotton when thus washed ought to be of a beautiful white.

Ninth Operation; galling,

For the galling, we must choose good galls in forts (a term employed in commerce to denote

denote black and white galls mixed together in equal quantities) and having bruised them, put for each hundred pounds of cotton, twelve pounds and a half into a copper, and boil them in six buckets of clear river water. Three hours are generally required to boil them sufficiently; we perceive that this is accomplished when they break between the fingers like *boullie*; three buckets of cold water are then added, and the whole passed through a very close hair sieve, squeezing with the hand what has not passed through, in order to separate all the resinous particles. When the water has settled and become clear, the galling is to be performed in the following manner.

Nine or ten quarts of the galling is poured into an earthen pan set in the wall at a height convenient for working, and the cotton is dipped in it by separate hanks, working it well with the hands; it is then wrung with the pin, and carried out to be dried as fast as it is dipped, a precaution essentially necessary to prevent the cotton from growing black.

When the cotton is thoroughly dried we proceed to the aluming, in the following manner.

Tenth Operation ; aluming.

The copper in which the decoction of galls was made being well cleaned, eight buckets of river water and eighteen pounds of roman alum are put into it, and the alum dissolved without boiling ; when the solution is complete, half a bucket of soda ley at four degrees of the areometer is added, and the cotton then wrought in it hank by hank as in the galling ; it is then spread out to dry, and afterwards washed from the alum as follows.

Eleventh Operation ; washing from the Alum.

Having left the cotton to soak and drain for an hour upon the horse, each hank is washed separately three times, wrung with a pin, and carried to the tenter ground.

Twelfth Operation (remonter sur galle.)

This operation consists in a repetition of the former ones. A white bath is prepared similar to that described in article 3 ; twelve pounds and a half of good Provence oil are put into a vat, and eight buckets of ley, at two degrees of the soap-maker's areometer, added to it,
and

and the bath being well stirred, the cotton is dipped in the manner described in article 3.

Thirteenth Operation ; first Salt.

The cotton after being well dried is dipped in a ley at three degrees.

Fourteenth Operation ; second Salt.

After the cotton has been well dried, it is dipped in a ley at four degrees.

Fifteenth Operation ; third Salt.

When the cotton is again dry, it is dipped in a ley at five degrees, and this concludes the dips : after being dried, it is washed, galled, and alumed, with the same proportions and attention to the same circumstances as in articles 9, 10, and 11 : the cotton has now received all the preparations necessary for taking the dye, and ought to be of the colour of the bark of a tree. A very essential circumstance to be attended to, is, never to dip the cotton until it is perfectly dry, otherwise we run the risk of rendering the colour spotted. When the cotton is hung out upon the poles, it must be frequently shaken and turned to make it dry uniformly.

Sixteenth Operation ; the dyeing.

A copper of an oblong square form is generally employed, which ought to be capable of holding about one hundred gallons, in which quantity twenty-five pounds of cotton may be dyed at once. The process for dyeing is begun by filling the copper with water within four or five inches of the brim, and pouring in a pailful of bullocks blood, or what is still better when it can be procured, sheeps blood (this is equal to about five gallons) and then adding the lizary. When we wish to obtain a fine bright colour, which penetrates, and has a good body, we commonly mix several kinds of lizary together, as one pound and a half of lizary of Provence, half a pound of lizary of Cyprus ; or if these cannot be had, a pound of that of Provence, with as much of the lizary from Tripoli or Smyrna, allowing always two pounds for one of cotton. When the lizary is in the copper it is stirred with the rake, to break the clods or lumps, and when the bath is warm, the cotton is put in on skein sticks, two hanks commonly on each ; care must be taken to immerse it properly, and to turn the cotton on the skein sticks by means of a pointed stick passed along them within the hanks. This process

cess is continued for an hour; and when the copper begins to boil, the cotton is taken off the skein sticks, and immersed in it, each hank being suspended by means of a cord passed through it, to sticks supported over the copper. The cotton ought to boil about an hour, in order to extract all the colouring matter from the madder. There is also a method of discovering when the colour is extracted, by the formation of a white froth on the copper. It is now taken out, and washed knot by knot at the river, wrung with the pin, and dried.

Seventeenth Operation; brightening.

Soda ley at two degrees is poured into the copper used for scouring, which should hold a hundred and fifty gallons of water, and it is then filled within ten or twelve inches of the brim; four or five pounds of olive oil are then added, and six pounds of white Marseilles soap cut very small; it is kept stirring until the soap is dissolved, and when the copper begins to boil, the cotton is put in, a cord being previously passed through it to prevent its being entangled: the copper is then covered up, and stopped with rags, loaded and made to boil gently for four or five hours; the cover being now taken off, the cotton should appear finished,
and

and of a beautiful red. The cotton must not be taken out of the copper for ten or twelve hours, because it improves in the bath and acquires a much greater degree of brightness.

It must be well washed knot by knot, and dried, and the operation is complete.

I am in the habit of giving my cottons a dip after they have become quite dry ; I make a solution of tin in aqua fortis, taking for a hundred pounds of cotton three or four pounds of aqua fortis at twenty-six degrees^d, to which I add an ounce of sal ammoniac for each pound, and then dissolve in it six ounces of fine tin in grains ; I add to the bath a pound and a half of mineral crystal ; I then dilute the mixture with eight buckets of water, and dip my cotton ; it must then be washed ; this dip gives the cotton a very fine fire (feu).

N. B. Only the residua of the first preparations are to be put into the sickiou ; those which remain after the cotton has been galled are of no use, and must be thrown away.

Mr. Gren has published some experiments which throw a great deal of light on the

^d To distilled water as 1220 to 1000. T.

theory of the Adrianople red *. He took two ounces of spun cotton, on which he poured fresh oil, and left it to soak for fifteen days, taking care to work the cotton well with it from time to time ; he then squeezed out the oil as much as possible, and put the cotton into a boiling solution of barilla. After boiling it for half an hour, he poured out the ley which had a milky appearance, and supplied its place with fresh urine, in which he boiled the cotton a quarter of an hour ; but he has ascertained, that water may be substituted for the urine. He made a decoction with half an ounce of alum and two drams of sumach, and put the cotton which had been well washed into it while boiling hot, and kept up the ebullition for an hour : after which he let it cool, and kept the cotton in it twelve hours ; when taken out of this bath, it was dried in the shade, washed in cold water, and dyed with a decoction of half an ounce of madder : he chose whole roots of madder the most slender he could find, cut them into small pieces, and pounded them. He left the cotton to grow cold in the bath. When washed, it shewed a very fine colour, which differed from the true

* Crell neueste entdeckungen, vol. iii.

Turkey red cotton only in lustre, which it did not possess in so high a degree, but it sustained the same proofs; thus it retained its colour after being washed in boiling water; the brightness of the colour was increased by washing in a cold ley of ashes; vinegar did not change it; exposure to the sun and air for three weeks produced no sensible alteration in it.

Ground madder of a middling quality, produced under similar treatment, a dirty brown colour without any brightness; but Zealand madder of a good quality produced a colour similar to the former.

The addition of fixed alkali, even in small quantity to the decoction, produced a deeper colour. The addition of solution of tin gave the colour a more pleasing hue.

Mr. Gren obtained only a bad colour which simple washing discharged, when he used pure or caustic pot-ash instead of soda; but carbonate of pot-ash succeeded as well as soda, when care was taken to squeeze out the oil from the cotton previous to its being put into the solution of the salt; if the oil was not squeezed out, the colour was but indifferent: whence he infers, that the alkali ought not to be so caustic as to deprive the cotton entirely of the oil, while at the same time, it ought to possess
sufficient

sufficient activity not to allow it to retain too much. These experiments also evinced, that in order to produce a red similar to that of Adrianople, it was necessary to choose the best kind of madder, and to prefer the whole roots, rejecting those which are too old, too woody, or rotten. When he employed different kinds of the ground madder, he most commonly obtained a dark brown colour instead of a red, notwithstanding all the attention he could employ in the coction.

I have repeated the process of Mr. Gren, a great part of the numerous and interesting experiments of Mr. Vogler, and have made some others of my own, of which I shall now give the results.

I have found, that the acetite of alumine formed by the mixture of alum, and the acetite of lead or salt of saturn, as already explained in the first part, was a better mordant than alum, for fixing the colour of madder, and that it was still more efficacious, when it contained an excess of acid, as it is prepared for the printing of linens, and as Mr. Willon directs.

Alum saturated with pot-ash to such a degree as to afford a slight sediment, was also a much more efficacious mordant than alum, probably

for the same reason. Solution of arsenic in pot-ash produced a similar effect, and even seemed to be superior.

Galling renders the colour more fixed and appears to darken it a little; yet galling is employed in the Adrianople process. Galls cannot be mixed with madder, because they prevent the extraction of its colouring part. I have always begun my processes by galling, after having ~~galled~~ leyed the cotton.

Leying renders the cotton more disposed to become saturated with colour.

I have made the same observation as Mr. Vogler, that mucilages and gums render the colour more fixed, but that glue in particular produced this effect: it combines with the alumine and the cotton, and thus imparts to the cotton the property of animal substances.

Complete exsiccation between each of the processes is very useful; when the water is expelled, its attraction no longer opposes the combination or decomposition of the mordant to which it proved an obstacle. It appeared to me a matter of indifference whether the exsiccation was quick or slow, provided however it was not too rapid, because of the crystallizable salts, the alum for example, for then, the solution exsudes before it is decomposed
and

and crystallizes on the surface; in which case the dyers say that it has run. This is probably the reason for directing that the exsiccations should be conducted in the shade and not in the sun.

I have found that long maceration and long continued boilings with the mordant were useless, and that it was sufficient if the cotton was well impregnated with the mordant: It has appeared to me for example, that no greater effect is produced by repeating the aluming two or three times successively, than by one operation properly conducted.

If only the saturation and permanency of the colour were attended to, we should from my experiments begin by leying the cotton, galling, drying and soaking it in the mordant composed of alum, and the alkaline solution of arsenic, or in the saturated acetite of alumine; we should then dry it, soak it in a solution of gluc, dry and wet it, that it may not take the colour unequally, and lastly, dye it in a madder bath, containing gluc. If we add common salt to one of the first preparations, the dye is still stronger (*plus forte*); but the colour obtained in this manner and by similar processes, is browner and much less bright than the Adrianople red.

Of the two processes, by means of which I came nearest the Adrianople red, without using a consistent oil, the one was by employing as mordant, a solution in the nitric acid of the precipitate from alum by common pot-ash; the other was by adding oxyd of tin to the madder bath. By this last process, I obtained a red which might easily be confounded with that of Adrianople: I shall compare their durability hereafter.

I repeated the process of Mr. Gren with success, substituting galls for the sumach; but the colour which I obtained, and which came very near the Adrianople red, withstood the action of leys, soap, and the air, less powerfully.

We have seen that Mr. Vogler had not succeeded by impregnating the cotton with oil; and yet without a greasy substance, we cannot obtain a colour like the Adrianople red. The intestinal liquor of sheep employed in the Adrianople process under the name of sickiou, seems to act by means of the grease which it contains, and by a substance analogous to the serosity and gluten found in all animal substances.

Mr. Pallas relates in the Petersburg journal for 1776, that the Armenians, whom the troubles

troubles in Persia obliged to retire to Astracan, dye Turkey red by alternately impregnating the cotton with fish oil and drying it, for seven days ; that they have observed that other oils do not succeed, and that they do not even use the oil of all fish indiscriminately, but choose that which becomes milky upon being mixed with an alkaline solution. After these repeated impregnations and exsiccations, they wash the cotton and dry it : they then give it an astringent bath to which a little alum is added ; they dye it in a madder bath with which calves blood has been mixed ; finally, they digest it for twenty-four hours in a solution of soda. It would seem that Mr. Vogler had not remarked, that the cotton should be deprived of the oil only to a certain degree by means of the ley.

The following observations prove that in the Adrianople red, the cotton has retained a little of the oil. A skein of cotton having been soaked in soap-suds and wrung slightly, was dried and then immersed in a mordant of alum saturated with pot-ash, afterwards dried, and dyed ; it had only a well saturated madder colour ; after two minutes boiling in weak soap-suds, it came out with the shade of

Adrianople red : its durability was not examined.

If cotton dyed with madder in any way be boiled for some minutes in soap-suds, it acquires a rose colour (rosé) ; if it be then squeezed, a greasy matter is pressed out, which has the colour of Adrianople red, and which fixes on white cotton. Mr. Œtinger has observed ^f in 1764, that oil had the property of dissolving the colouring matter of the Adrianople red, so that if it be moistened with oil, its colour is communicated to white cotton when rubbed with it for some time. He had thence concluded, that oil must enter into the preparation of Adrianople red, and the Abbé Mazéas has long ago proved that the use of oil in that dye was indispensable ^g.

The kind of madder employed has great influence on the colour produced. It appears absolutely necessary to employ that which is called lizary, in order to obtain a colour equal to the Adrianople red.

^f Dissert. de viribus radic. rubiæ tinct. antirachiticis a virtute ossa animal. vivorum tingendi non pendentibus.

^g Recherches sur la cause phys. de l'adhérence de la couleur rouge, &c. Mem. des Sav. étrang, tom. iv.

With respect to the choice of madder, we must recollect that Messrs. d'Ambourney and Beckmann recommend the use of fresh madder; but it is generally supposed that it gives a more beautiful colour when kept for a year or two before it is used, and Mr. Gühliche says, that the old madder gives a colour nearly as beautiful as lizary. There are cases perhaps in which the use of fresh madder would be advantageous; the choice of the young roots would certainly be proper.

Having exposed for a long time to the inclemencies of the weather, the cotton which I had dyed with the addition of oxyd of tin to the madder bath, that, for which the solution of alumine in nitric acid had been employed as mordant, and a pattern of Adrianople cotton; the colour of the first remained longest without any sensible change; at last however it acquired a yellow hue; the second acquired a yellowish tinge sooner; the colour of the third was impaired soonest, but it did not change its hue (ton).

From this experiment it follows, that we may consider in cotton dyed with madder, its power of resisting the action of the air for a long time, or that of resisting alkalis or soap. This last can only be obtained by means of

oils and grease, but the first depends principally on the mordants employed, and the number of dryings. It is therefore proper, independant of the beauty of the colour, to employ processes similar to that of Adrianople, for such stuffs as are to be subjected to leying or frequent washing with soap.

Mr. Wilson makes an observation which is worthy of attention. He says that stuffs made of cotton, which has not been spun by Mr. Arkwright's machines, cannot be dyed by the Adrianople process, because the filaments of the cotton are made to bristle up (*se hérissent*) in the numerous operations of this process; but that these filaments preserve their parallelism much better when the cotton has been spun and carded by these machines, and that the stuffs can then undergo the same operations without injury to their texture ^b.

But as colours which sustain the action of the air as well as the Adrianople red, may be obtained by shorter processes, and as cotton stuffs are not intended to be submitted to leying and frequent washing, processes analogous to some of those described above, may frequently be employed with advantage.

^b An essay on light and colours, &c.

One circumstance which I ought not to omit, is that the oxygenated muriatic acid represented the action of the air on the madder reds exposed to its influence, indicating the patterns which would resist its action most powerfully ; while the nitric acid on the contrary indicates the cotton dyed in the Adrianople manner, by giving it a yellow colour, as Mr. Vogler has observedⁱ ; this effect seems to depend on the combination of the animal oil with the cotton, to which, as to all other animal substances, the nitric acid gives a yellow colour, by destroying the proper colour of the madder : it is this combination of animal oil with the cotton which forms the distinguishing characteristic of this species of dye : a different kind of oil might produce a bright colour, but probably it would not be so durable.

I have also tried the oxyd of tin in dyeing wool. The decoction of madder acquires a more clear and lively red by the addition of this oxyd ; its colouring particles became fixed much more quickly and more abundantly, upon

ⁱ I believe that Mr. Beckmann made this interesting observation before Mr. Vogler. *Physical Æcon. Bibliothek.* vol. iv.

cloth which had been prepared by a decoction of alum and tartar in the ordinary manner. The cloth came out of the dye bath of a much more saturated and beautiful red, than a similar pattern dyed with an equal weight of madder, without oxyd of tin; the advantage however does not appear to me so great, as to render the process worthy of being commonly employed.

Oxyd of zinc used instead of tin, produced a fine orange colour in the cloth; oxyd of lead a dull brick colour; that of iron had no sensible effect.

The above observations on madder may admit of numerous applications, in the very extensive and various uses for which it is employed, especially in the dyeing of cotton and linen. It is a substance which merits particular attention upon account of the advantages it may afford by its cultivation.

C H A P. III.

Of Cochineal.

COCHINEAL was at first supposed to be a grain, but naturalists soon discovered that it was an insect. It is brought to us from Mexico, where the insect lives upon different species of the opuntia. The body of the female is flat on the belly and hemispherical on the back, and marked with transverse wrinkles. The skin is of a dark brown; the mouth is a tubular point which issues from the side of the thorax: it has six very short brown legs and no wings; the body of the male is rather long, of a deep red colour, and covered with two wings extending horizontally, and crossing a little upon the back; it has two small antennæ on the head, and six legs, which are larger than those of the female; it has not a direct flight but flutters, hopping very seldom; its life, which is only of a month's duration, terminates by its amours; and the fecundated female lives a month longer, and dies after parturition: the female is sometimes oviparous and sometimes viviparous. The young females when brought forth disperse themselves upon
the

the joints of the opuntia, where they remain fixed by their trunk (trompe) till the end of their life.

Two sorts of cochineal are gathered at Mexico; the *sylvestris*, there known by the spanish name *grana sylvestra*, and the fine, or *grana fina*, called also Mesteque, from the name of a province of Mexico, and which are bred upon the nopal. The first is smaller, and covered with a cottony down, which increases its weight with a substance which is useless in dyeing: an equal weight of it therefore gives less colour and is of a lower price than the fine cochineal; but these disadvantages are perhaps compensated by its being reared with greater facility, and at less expence, and even by the effects of its down, which enables it the better to resist rain and storms.

The coch. sylvest. when bred upon the nopal, loses part of its tenacity, and some of its cotton, and acquires double the size it has on the other species of opuntia. It is therefore to be hoped that it would be improved by a continued attention to the rearing of it, and would approach more and more to the fine cochineal.

M. Thieri de Menonville was led by his patriotic spirit and personal courage, to expose himself

himself to imminent danger, in going to observe the mode of rearing the cochineal in Mexico, in order to obtain from thence that valuable production, wherewith he might enrich the colony of St. Domingo. He brought back with him both species of cochineal, and nopals, the kind of opuntia which affords the best food for these insects.

Upon his return, he employed himself in the cultivation of the nopal and different kinds of opuntia, and in rearing the two species of cochineal; but death cut off that excellent citizen, and the fine cochineal soon perished.

When he returned to St. Domingo, he discovered the cochinita sylvestris upon a kind of opuntia called *péreschia*, or *patte de tortue*, which grows there. This discovery did not remain unprofitable: M. Bruley employed himself successfully in rearing this species of cochineal; he communicated it to the cercle des Philadelphes*, who do not lose sight of that object, and have published a posthumous work of M. Thieri de Menonville, which contains very minute instructions with regard to every thing that respects the cultivation of the nopal,

* Now the Royal Society of Arts and Sciences at Cape François. T.

and the other species of opuntia that may be substituted for it more or less successfully, for breeding or rearing the cochineal ^b.

Two months after the females, which have been reserved, are sown upon the nopal, the young cochineals are observed to issue from them; and then is the proper season for gathering them: they are killed by immersion in boiling water. The hot iron plates or ovens which are sometimes employed may injure the cochineal by being too hot. When taken out of the water, they are carefully dried by free exposure to the sun. They lose nearly two thirds of their weight in drying.

When the fine cochineal is dry, it must be passed through a sieve sufficiently coarse to allow it to go through, but capable of retaining the down and cotton of the larvæ of the males. These are kept apart and sold separately, or with the cochinilla sylvestris.

Fine cochineal, which has been well dried and properly kept, ought to be of a gray colour inclining to purple. The gray is owing to a powder which covers it naturally, a part

^b *Traité de la culture du nopal & de l'éducation de la cochenille dans les colonies Françaises de l'Amerique précédé d'un voyage a Guaxaca; par M. Thieri de Ménonville. Ann. de Chym. tom. v.*

of which it still retains: the purple tinge proceeds from the colour extracted by the water in which it has been killed.

Cochineal will keep a long time in a dry place. Hellot says, that he tried some, one hundred and thirty years old, and found it produce the same effect as new.

It has been pretty generally supposed, that cochineal owes its colour to the nopal on which it lives, the fruit of which is red. But Mr. Thieri de Menonville observes, that the juice which supplies it with nutriment is greenish; and that it can live and propagate its species, on such kinds of opuntia as do not bear red fruit.

The decoction of cochineal is of a crimson colour, inclining to violet.

A small quantity of sulphuric acid made this liquor assume a red colour, inclining to yellow, and a small quantity of a beautiful red precipitate was formed.

Muriatic acid produced nearly the same change in the colour, but no precipitate.

Solution of tartar changed the liquor to a yellowish red. A little precipitate of a pale red colour formed slowly: the supernatant liquor remained yellow, but on pouring in a little alkali, it became purple. The small quantity

tity of precipitate was quickly dissolved by the alkali, and the solution was purple. Solution of tin formed a rose-coloured precipitate with the yellow liquor.

Solution of alum brightened the colour of the infusion, and gave it a redder hue: a crimson precipitate was formed, and the supernatant liquor retained a crimson colour, somewhat reddish.

Alum and tartar mixed, produced a brighter colour, more lively, and inclining to a yellowish red. A precipitate was formed, but much less abundant, and much more pale, than in the preceding experiment.

Solution of tin produced a copious sediment of a beautiful red. The liquor remaining above it was as clear as water, and suffered no change of colour on adding alkali.

Having poured in a solution of tartar, and after that, solution of tin, a precipitate of a rose colour inclining to black was formed more quickly than in the foregoing experiment; and, though solution of tin in excess was added, the supernatant liquor remained a little yellow.

Solution of muriat of soda rendered the colour somewhat deeper, but did not make the liquor turbid.

Ammoniacal muriat gave a purple tinge, without occasioning any precipitate.

Sulphat of soda, produced no perceptible change in the liquor.

Having boiled a little cochineal with half its weight of tartar, the liquor was more inclining to red, and had a colour much less deep, than that obtained from an equal quantity of cochineal without tartar: but the former gave a more abundant precipitate with solution of tin, and its colour was more rosy: so that tartar favours the solution of the colouring part of the cochineal: for, though the colour of the solution is less deep, the precipitate produced from it by solution of tin, is of a deeper and more rosy hue. This experiment deserves notice, in judging of the influence of tartar in dyeing scarlet.

• Sulphat of iron formed a brown violet precipitate. The supernatant liquor remained clear, with a tinge of feuillemort.

Sulphat of zinc formed a deep violet precipitate. The supernatant liquor remained clear and colourless.

Acetite of lead produced a purple violet precipitate, less deep than the preceding. The supernatant liquor remained limpid.

Sulphat

Sulphat of copper produced a violet sediment, which formed slowly. The liquor remained clear, and of a violet colour.

If the extract which decoction of cochineal affords on evaporation be digested in alcohol, the colouring part dissolves, and leaves a residuum of the colour of wine-lees, of which fresh alcohol cannot deprive it. This residuum, analyzed by fire, affords the common products of animal substances.

The alcohol of cochineal, leaves on evaporation, a transparent residuum of a deep red, which, when dry, has the appearance of a resin. This also, if distilled, yields the products of animal substances; which shews, that the colouring matter is an animal production.

Yet the decoction of cochineal does not easily putrefy. I have kept some of it more than two months, both in an open vessel, and in a bottle corked. At the end of that time, the former shewed no signs of putrefaction: the latter had a slight putrid smell. The first grew turbid in a few days, and left a brown violet sediment on the filter: the second preserved its transparency a long time, and probably lost it only from the effect of an incipient putrefaction, or rather of a slight combustion, produced by means of a little oxygen, probably united with
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the red particles of the cochineal. The colour of each had become crimson: but that of the former was more weak, because a greater part of the colouring matter had precipitated, in consequence of the effects produced on it by the air, agreeably to the principles established in the first volume.

I have compared the *cochinilla sylvestris* of Mexico, and some which had been cultivated at St. Domingo, and sent over by Mr. Bruley, with the masticque cochineal.

The decoction of the *sylvestris* has the same hue as that of St. Domingo. This inclines more to crimson than that of the masticque: but the precipitates obtained from it either by solution of tin, or by alum, are perfectly equal in colour to those from the masticque cochineal; and to these precipitates the stuffs with which they combine owe their colour.

To determine the proportion of colouring matter contained in decoctions of different cochineals, I employed oxygenated muriatic acid. Of each of the three cochineals above mentioned I boiled an equal weight for an hour, rendering the circumstances with regard to each as nearly similar as possible. Having filtered the decoctions, I poured them into separate graduated glass cylinders, and added to them

oxygenated muriatic acid, from the same bottle, till they were all reduced to the same yellow hue. The quantities of acid which indicated the proportions of the colouring matter were found to be nearly as follows: for the cochineal of St. Domingo, eight; for the *sylvestris*, eleven; for the *maïlique*, eighteen.

It appears, then, that the cochineal of St. Domingo is not only greatly inferior to the *maïlique*, but even to the *sylvestris* of Mexico; and in fact it is much smaller, and more downy; but these disadvantages ought not to abate the zeal of those who are engaged in its cultivation.

The observations of Mr. Thieri de Menonville have already proved, that the *cochinilla sylvestris* loses its down, and increases in size, by a succession of breeds carefully attended to, though at first he was obliged to use nopals not come to the proper growth. There is every reason to hope therefore, that the St. Domingo cochineal may, by assiduous care, be brought to equal, or perhaps surpass the *sylvestris* of Mexico: but should it always remain inferior with respect to the quantity of its colouring matter, this would be by no means a sufficient reason to neglect a substance so valuable in dyeing.

It has been seen, that the cochineal of St. Domingo is not inferior to the masticque, as to the quality of its colour. If then, the down with which it is covered proves detrimental, in operations on a large scale, to the beauty of scarlet, the lustre of which is so easily injured, it might be advantageously employed either for scarlet in half grain, or for crimson, and other shades, which are less delicate than that, which is the brightest of all colours.

To form an idea of the utility of which cochineal may be to St. Domingo, possessed of so many rich productions, is difficult. Mr. Thieri de Menonville considers it as a valuable resource for those parts of the island, the unfruitful soil of which is not adapted to the other produce; and for those colonists who are unable to support the expence attending the cultivation of other crops. Mr. Bruley speaks still more favourably of the advantages to be expected from the culture of cochineal: but the cercle des Philadelphes is more reserved, and thinks, that the point is not yet to be decided upon.

The attempts that have been made deserve so much the more to be pursued and encouraged, as they have for their object an important branch of commerce, and as enlightened in-

dustry has great advantages over ignorant indolence. It will be found less difficult perhaps to naturalize cochineal, at least in hot countries, than it was to naturalize silk-worms.

A distinguishing characteristic between cochineal and madder, may be observed in the manner in which they are acted on by reagents. Both receive a yellow colour from acids: but if the colouring matter of cochineal be separated by a substance which precipitates it from the acid liquor, it reappears, with its natural colour little altered; whilst that of madder, treated in the same manner, retains a yellow or fawn tinge. Hence mordants abounding in acid, as solution of tin, are much more successfully employed with cochineal than with madder. The cause of this probably is, that the colouring matter of madder united with oxyd of tin retains a portion of acid, whilst that of cochineal combined with it retains none, or a much smaller quantity.

Carmin is the lake obtained from cochineal by means of alum: but when the cochineal is mixed a certain proportion of Nutour, a bark brought from the Levant, of a colour paler than cinnamon, and in general chouan, a yellowish green seed, of an unknown plant, likewise brought from the Levant, is also added.

It

It is probable, that these two substances furnish with alum a yellow precipitate, which serves to brighten the colour of the cochineal lake, as a yellow colouring matter gives scarlet the colour of fire. Carmine was formerly prepared from kermes, whence its name is derived.

C H A P. IV.

Of Dyeing Scarlet.

SCARLET is the finest and most splendid colour in the art of dyeing. The same taste with respect to the shade that is preferred does not always prevail: sometimes it is required to be of a deeper and more perfect red, at others, to incline more or less to the colour of fire.

We cannot expect to obtain the desired shade from the precise proportions prescribed in the processes, because the quantity of colouring matter contained in different kinds of fine cochineal varies, and still more, because the solutions of

tin employed, may differ considerably from each other: but it is easy to ascertain, by trials on a small scale, the proper proportion of ingredients to be used for obtaining a particular shade; and if the pieces dyed be found to go beyond the point, or fall short of it, it is difficult to bring them to it. I shall first describe the chief of the processes known, and afterwards endeavour to lay down principles by which the colour may be modified at pleasure.

As I have already treated at length of the solution of tin, called by dyers *composition*, on this subject I shall refer to the third section of the first volume. For the processes also, by which hard water is rendered more pure, the chapter in which they are described may be consulted; the water employed for this dye requiring particular attention.

Dyeing scarlet is performed at two operations: the first is called the boiling; the second, the finish or reddening (*rougic.*)

For the boiling designed for dyeing a hundred pounds of cloth, six pounds of pure tartar are thrown into the water when a little more than warm. The bath is stirred briskly, and when it is a little hotter, half a pound of powdered cochineal is added, and well mixed. A moment after, five pounds of very clear solution

solution of tin are poured in, and carefully mixed. As soon as the bath begins to boil, the cloth is put in, and moved briskly for two or three turns, after which it is moved more slowly. When it has boiled a couple of hours, it is taken out, aired, and carried to the river to be well washed.

To prepare the second bath, which is the reddening, the boiler is to be emptied. When the bath is ready to boil, five pounds and three quarters of cochineal powdered and sifted are put in. These being carefully mixed, when after having ceased stirring, a crust, which forms on the surface, opens of itself, in several places, thirteen or fourteen pounds of solution of tin are poured in. If, after that, the bath rise above the brim of the boiler, it is to be cooled by the addition of cold water.

When the solution is well mixed, the cloth is to be put into the bath, taking care to turn it quickly the first two or three turns. In this bath it is boiled for an hour, pushing it down with a stick when the boiling raises it up. It is then taken out, aired, and cooled; after which it is washed in the river, and dried.

The proportions of cochineal, and of solution of tin, put either into the boiling, or into the reddening, are not fixed. There are dyers,

who according to Hellot's account, succeed very well by putting two thirds of the composition, and a fourth of the cochineal into the boiling, and the remaining third of the composition, with the remaining three fourths of the cochineal, into the reddening. Hellot asserts also, that it does no harm to use tartar in the reddening, provided not more of it than half the weight of the cochineal be put in; and it has appeared to him even to render the colour more permanent. This is at present the practice of several dyers. It has been seen, that tartar promotes the solution of the colouring matter, an effect that especially occurs when it is ground with the cochineal, whence the residuum is more completely exhausted. This consideration is of less weight, when the operations are performed one after the other, because then the colouring matter left in the residuum is employed in the subsequent operations. But we must not forget the effect the tartar has on the quality of the colour, to which it tends to give a rosy hue, as has been already seen.

Some dyers do not take the cloth out of the boiling, only refreshing it, to make the reddening in the same bath, by pouring in an infusion of cochineal, which they have made apart, and
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with which they have mixed the proper quantity of composition. In this way they save time and fuel and they assert, that the scarlet is equally fine.

As scarlet is in general required to be very lively, and to approach the colour of fire, a yellowish tinge is given it by boiling fustic in the first bath, or by adding a little turmeric to the cochineal. The yellow tinge might be obtained by increasing the quantity of composition: but this has the inconvenience of rendering the cloth harsh, and even of preventing the colouring matter from fixing in it in a certain quantity. Thus, though neither fustic nor turmeric gives a permanent colour, it is better perhaps to use them in small quantity, than to add too much solution of tin. That these ingredients have been used is discoverable by cutting the cloth, the inside of it appearing in that case yellow; whilst in the common processes the cochineal does not penetrate the cloth, leaving it internally white, when it is said to *cut*.

In dyeing scarlet it is of advantage to use tin boilers, because the acid employed attacks copper, and the solution it forms with it may injure the beauty of the colour. But as these are difficult to make of any considerable size,
and

and are liable to melt, if the workmen forget to withdraw the fire before emptying them, many dyers use copper ones. It is necessary however, to keep these very clean, not to let the acid liquor remain in them, and to prevent the cloth dyed in them from touching the copper, by means either of a net, or of an open-work wicker basket.

Scheffer directs for the boiling, an ounce and a half of solution of tin, with an equal quantity of starch, and as much tartar, to every pound of cloth. He observes, that the starch serves to render the colour more uniform ; and he directs, to throw into the water, when it boils, a dram of cochineal, to stir it well, to boil the wool an hour, and afterwards to wash it. The wool is then to be boiled half an hour in the reddening bath, with half an ounce of starch, three quarters of an ounce of solution of tin, half an ounce of tartar, and seven drams of cochineal.

It appears, that Scheffer employs a much smaller quantity of solution of tin than Hellot : but his solution, the manner of making which has already been given, contains much more tin.

Mr. Poerner describes three principal processes, according as the shade of the scarlet is

to be more or less deep, or more or less inclining to orange. He puts no cochineal into the boiling, which he composes of one ounce six drams of tartar, and an equal weight of solution of tin, added after the tartar is dissolved, for every pound of cloth. After it has boiled a moment, he puts in the cloth, and lets it boil two hours.

For the reddening of the first process, he uses two drams of tartar, and an ounce of cochineal ; afterwards pouring in gradually two ounces of solution of tin.

For the reddening of the second process, he uses the same quantity of cochineal, and two ounces of solution of tin, without any tartar.

For that of the third, he directs two drams of tartar, an ounce of solution of tin, and two ounces of common salt, with the above quantity of cochineal.

The scarlet of the first process is of the deepest shade ; that of the second is less full, but more lively ; that of the third is still more bright and pale.

Tartar, as has been seen, gives a deeper and more rosy hue to the colouring matter of cochineal precipitated by solution of tin. It moderates the action of the nitro-muriatic acid, which

which tends to give scarlet an orange cast, though this orange cast is not to be seen in the precipitate produced by the solution of tin, which is on the contrary, of a fine red. It is probable, that the solution of tin gives scarlet an orange tinge, by means of the action the nitro-muriatic acid exerts on the wool, which, as well as all other animal substances, it has the property of turning yellow.

Thus by putting more or less tartar into the reddening, a deeper and fuller scarlet may be obtained ; and, on the contrary, the scarlet may be rendered more inclining to orange, by omitting this ingredient.

But the solution of tin may also influence the colour, according to the proportions of tin and ammoniacal muriat it contains. On this subject I have made various experiments.

A solution of tin made with sixteen parts of nitric acid, at thirty degrees of Baumé's aréometer, two parts of ammoniacal muriat, and three parts of tin, gave a less lively and somewhat deeper colour, than a solution in which the acid and ammoniacal muriat were in the same proportions, but which contained only two parts of tin. These last mentioned proportions succeeded with me best of many
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which I tried. I mix with the solution four parts of water. Putting only half a part of muriat of ammoniac, the colour was more bright, and inclining to orange. In fine, by using a solution of murio-ammoniacal salt of tin, which contained near half its weight of oxyd of tin, and adding to the solution a little muriatic acid to prevent the precipitation of the metal, I obtained a crimson colour: but on adding tartar in the reddening, the cloth took a beautiful deep red, which resisted the oxygenated muriatic acid better than common scarlet. It is to be observed, that when this salt is used, the bath is exhausted more readily and more completely than with the common solution of tin.

Scarlet may be brightened by common salt; and the colour will at the same time penetrate deeper, and leave less cut. Muriat of ammoniac also renders the colour more bright and pale, but it carries the effect too far.

I cannot explain the reason why common salt, which deepens a little the colour of infusion of cochineal, and produces the same effect on colours in general, should diminish the intensity of scarlet.

Mr. Poerner observes, that the proportion of common salt he directs is the greatest that
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can be employed ; and that a more agreeable shade, though lighter, will be obtained, if less be used. He says, that the addition of five ounces of white sugar to the ingredients of the second process will produce a finer colour, which is always lighter than that of the first process. He asserts, that a more pleasing and more permanent colour will be obtained, if the cloth be left in the boiling twenty-four hours after it is cold.

If the scarlet which has been just dyed be found to have too much of the orange cast, this may be weakened by washing with hot water, especially if the water contain any salt with an earthy base.

The reddening which has been used for dyeing scarlet is not exhausted of its colouring matter, but still contains a portion which varies in quantity according to the fineness of the powder, to which the cochineal was reduced, and the length of time it has been boiled. This bath retains also a portion of the mordants which were put in. As the nature of this residuum however, is not always the same, it would be illusory to prescribe the exact quantities of the ingredients to be added, to obtain from it any particular shades : experience, and the habit of performing the same process, will

will easily guide an intelligent dyer: I shall confine myself therefore, to some general reflections.

If we have much cloth to dye scarlet, we may use for the boiling a reddening with which we have just dyed, taking from the ordinary quantity of cochineal as much as we suppose to be left in the bath, diminishing also the quantity of solution of tin. But if we would have a fiery colour, we must begin by boiling a bag of fustic, taking it out before adding the other ingredients.

After this the bath may be used, as soon as the cloth is taken out, for making pomegranate colour, boiling in it a bag of fustic. That which has already been in a bath, is fitter than new for this shade. As soon as this is taken out, some tartar and composition are put into the bath, which is well raked, and the cloth treated as for dyeing scarlet.

The bath may be used after this for capuchin colour (*les capucines*) boiling in it fustic, and adding tartar and solution of tin.

The preceding boiling may also be used for langouste, orange, cassis, gold colour, and jonquille, by boiling in it fustic, and adding a little cochineal, and more or less tartar, and solution of tin.

When

When all the cloths to be dyed have gone through the boiling, proceeding from the deepest colour to the lightest, they are to be passed through the reddening, proceeding contrariwise from the lightest to the deepest, adding more and more cochineal, and solution of tin, till we come to the pomegranate and fire colours. When it is come to the turn of the gold colour and jonquille, fustic is to be added, at least if they were not finished in the first bath, which as we shall see, may be done for some shades. For the gold colour and cassis a little madder is to be added.

The colours of gold, cassis, jonquille, and buff, may be made after the scarlet boiling, by adding for the former two, fustic, solution of tin, and a little madder; a little more fustic, and a little less solution of tin, for the first than for the second. For the buff much less solution of tin must be used. A dun colour (*colcur de biche*) may be made after boiling scarlet without any addition. *Le café au lait* requires a little fustic and solution of tin, and a very small quantity of madder: for *le chocolat au lait*, a little cochineal and tartar are added to the last mentioned ingredients.

For the boiling for cherry colours, a fresh bath composed of tartar and solution of tin, is generally

generally used. Afterwards, for dyeing them, a reddening that has been used for scarlet is employed, adding to it tartar, solution of tin, and a little cochineal. In boiling and reddening these, only half the time required for scarlet is taken up : and in general the time is shortened in proportion to the delicacy of the tint. For the boiling for rose colour the reddening of cherry colour may be employed, and its reddening composed of a little solution of tin, a little tartar, and a very little cochineal. The colour may be deepened by passing the cloth through hot water when it comes out of the dye.

Flesh colour (*couleur de chaire*) is made after a reddening, by throwing away a little of the bath, and cooling it. It may also be made after a violet colour, by adding a little solution of tin. It must boil but a short time.

Finally, the reddening from which scarlet has been taken out may be used for grays that are to have a purple (*vineux*) cast ; refreshing the bath with the addition of galls, and afterwards a little sulphat of iron, or green vitriol.

It must be observed, that weak and delicate tints, as langoustes and orange colours, as well as lilacs, mauves, cherry, and rose colours,

have more bloom and freshness when prepared in a single bath, than when they have gone through both boiling and reddening. It is only necessary to put into the bath the proper ingredients. The cloth simply wetted, and impregnated with no mordant, fills itself with the colouring matter less readily, and more evenly. In this way too, time and fuel are saved.

From what has been said, it appears, that for obtaining different shades of scarlet, and the colours derived from it, nothing more is necessary than to vary the proportions of cochineal, tartar, and solution of tin, and to add for the shades most inclining to yellow, fustic, for which other yellow substances are sometimes substituted. Tartar serves to deepen the colour : solution of tin makes it incline to orange. For light shades the time of operating must be shortened.

C H A P.

C H A P. V.

Of Dyeing Crimson.

ALL the processes employed for obtaining the different shades of crimson, from the deepest to the lightest, may be reduced to two. Either the shade of crimson desired is given to cloth previously dyed scarlet, or the cloth is dyed crimson at once.

Alum, salts with earthy bases in general, fixed and volatile alkalis, have the property of changing the colour of scarlet to crimson, which is the natural colour of cochineal. Nothing is necessary therefore, than to boil cloth dyed scarlet for about an hour in a solution of alum, proportioned in strength to the deepness of the colour desired. But as other salts with earthy bases have the same property, and water contains more or less of these salts, whence it gives a proportionate rosy tinge to scarlet passed through it, particularly if it be warm, the quantity of alum necessary to obtain a crimson varies according to the nature of the water employed: nay, if the water be loaded with earthy salts, it will answer the purpose of itself, without the addition of alum. When

a piece of scarlet has any defects it is made into a crimson.

Hellot says, that he has tried soap, soda, pot-ash, and cendre gravelée: that all these substances produced the crimson desired, but faddened it, and gave it less lustre than alum: that ammoniac on the contrary produced a very good effect, but, as it evaporates quickly, a considerable quantity must be put into the bath a little more than warm, a little ammoniacal muriat, or sal ammoniac, and an equal quantity of common pot-ash. In this method the cloth instantly took a very bright rosy colour. He asserts, that it heightens the colour so much as to render less cochineal necessary. Mr. Poerner, who gives the same process, directs the scarlet to be left twenty-four hours in a cold solution of ammoniacal muriat and pot-ash.

To dye crimson at once, a solution of two ounces and a half of alum, and an ounce and a half of tartar, to every pound of cloth, is used for the boiling: and the cloth is afterwards dyed with an ounce of cochineal. Solution of tin is commonly added, but in less proportion than for scarlet. The processes employed vary greatly, according as the shade required is deeper or lighter, or more or less distant from

from scarlet. Some use common salt for the boiling.

Archil and pot-ash are frequently used for faddening crimsons, and giving them more bloom; but the bloom thus imparted soon vanishes.

The boiling for crimson is sometimes made after a scarlet reddening, by adding tartar and alum: and it is asserted, that the *soupe au vin* has more bloom, if both its boiling and reddening be made after scarlet, than when it is dyed in a fresh bath. For these colours the *cochinilla sylvestris* may be used instead of the fine; but, as it contains less colouring matter, its quantity must be greater.

The reddening which has been used for crimson may be employed for purples, and other compound colours, which will be treated of hereafter.

Scarlets and crimsons in half-grain are made by substituting madder for half the quantity of the cochineal, giving the same boiling as for scarlet in grain, and following in other respects the processes for reddening the scarlet or crimson. Other proportions of madder may be used instead of half, according to the effect we would obtain. Common madder red, also ac-

quires a greater lustre, if its boiling be made after a reddening for scarlet.

In filk the grain crimson, produced by cochineal, is distinguished from false crimson, which is obtained by means of brasil wood.

Silk designed to be dyed crimson with cochineal, ought not to be boiled with more than twenty pounds of soap to a hundred of filk, as the slight yellow cast which filk has when only so far scoured is favourable to the colour.

When the filk is well cleansed from the soap at the river, it is to be put into an alum liquor of the full strength. In this, it is commonly left from the evening till the next morning; after which it is to be washed, and twice beetled at the river.

To prepare the bath, a long boiler is half or two-thirds filled with water; and when the water boils, white galls powdered are thrown in, from half an ounce to two ounces for every pound of filk. After boiling a few moments, from two to three ounces of cochineal, powdered and sifted, for every pound of filk, according to the shade required, are put in, adding afterwards an ounce of tartar to every pound of cochineal, and as soon as the tartar is dissolved, an ounce of solution of tin to every ounce

ounce of tartar. This solution ought to contain more tin than that used for scarlet, otherwise the colour would be too bright. Macquer directs it to be made with one pound of nitric acid, two ounces of ammoniacal muriat, six ounces of fine grain tin, and twelve ounces of water.

When these ingredients are mixed, the boiler is to be filled up with cold water. The proportion of the bath is about eight or ten quarts of water to every pound of silk. In this the silk is immediately dipped, turning it on the skein sticks till it appears to be of an uniform colour. The fire is then increased, and the bath made to boil for two hours, turning the silk from time to time. After this the fire is put out, and the silk put into the bath, where it is kept a few hours longer. The silk is then washed at the river, giving it two beetlings, wrung, and dried.

If crimsons are to be saddened, they must be passed, after having been washed, through a solution of sulphat of iron, more or less strong according to the shade required. If it should have a yellow tinge, a greater or less proportion of decoction of fustic is to be added to the solution.

White galls are chosen, because black would dull the colour of the crimson; and even too large a quantity of the white will produce the same effect. Macquer says, that the galls serve only to increase the weight of the silk: yet their general effect is to render colours more permanent, and they are at least indispensable for crimsons intended to be faddened.

Vinegar is used to distinguish grain crimsons from false: but this will not detect colours obtained from brasil wool, if they be fixed by means of solution of tin; as then, they stand the proof with vinegar as well as those made with cochineal.

In Macquer's treatise on dyeing silk, we find descriptions of the mode of dyeing it crimson at Damascus and Diarbekir, communicated by Granger, and of the process followed at Genoa.

It has been seen, that a very small quantity of solution of tin is put into the bath for dyeing silk crimson. If the same process as that for dyeing wool scarlet, were employed, the silk would lose its bloom, and acquire only a faint colour. Macquer and Scheffer, however, have both published processes which differ from it only in a few circumstances, for
dyeing

dyeing filk rose and poppy colours by means of solution of tin, used cold, that it might not act too violently on the filk.

In the process which Macquer published in 1768, the solution of tin is prepared from three pounds of tin, four pounds of nitric acid, and two pounds of muriatic. The acids being mixed, the tin is to be thrown in, a little at a time. When the solution is finished, six pounds of filk, that has already had an annotta bath, are to be put into it, and left there half an hour. The filk is then to be wrung, and washed as long as it makes the water foul. To dye it, four ounces of cochineal, and a quarter of an ounce of tartar, are taken for every pound: when the water into which these are put boils, cold water is added, till the hand can be suffered in it: the filk is then put in, the fire is increased, and the filk, after having been boiled a minute, is taken out and washed. By this process the filk acquires an increase of one-fourth of its weight. Its colour will stand soap, and is much more permanent than that given it by carthamus.

In 1751 Scheffer published in the swedish language a description of the following process. One part of tin is dissolved in a mixture of four parts of nitric acid and one of common salt,

falt. This solution being diluted with twice its quantity of water, the filk is left to steep in it for twenty-four hours; after which it is taken out, and washed in clear water till it no longer renders it milky. This filk is dyed by boiling a quarter of an hour with five-sixths of its weight of cochineal in a small quantity of water. The liquor remaining contains a considerable portion of colouring matter, which may serve for dyeing filk a lighter shade, or for dyeing crimson in the common way. It may also be used for dyeing wool.

Scheffer describes some variations in his process, for obtaining different shades. I shall relate the principal. If the filk be wrung out of the solution of tin, left all night in a cold solution of alum, an ounce to a quart of water, wrung and dried, then washed, and afterwards boiled with cochineal, it will take only a pale poppy colour. If the filk be steeped twelve hours in the solution of tin diluted with eight parts of water, then left all night in the solution of alum, washed, dried, and passed through two baths of cochineal as before, adding to the second bath a little sulphuric acid, it will be of a fine poppy red.

The chief difference in the two processes of Macquer and Scheffer consists in the yellow ground

ground which the former gives the silk. Schef-fer uses a greater proportion of cochineal in the dye bath.

In the experiments I have made on this subject, the solution of tin which succeeded best, was the same as I have directed for dyeing scarlet: this procured me a fine cherry colour, sufficiently bright. Solutions containing a greater proportion of tin gave me deeper shades: and the solution of the murio-ammoniacal salt of tin produced a dull deep crimson. Though I have varied my experiments in several ways, I have never been able to obtain a shade comparable to scarlet: and I have been informed by those who assisted at Macquer's trials at the Gobelins, that the silk dyed by his process never reached that colour. Scarlet, however, is so much in request, as to have excited artists to repeated attempts for obtaining it. Those who appear to have approached nearest to the desired end begin with dyeing the silk crimson; this dye they cover over with that of carthamus, by the process hereafter to be described; and lastly, they give it a yellow dye without heat. By these means a fine colour is obtained, but the action of the air destroys the dye of the carthamus, and soon darkens the colour.

Cochineal is little used for dyeing cotton and linen, because a fine and permanent red may be given them by means of madder. Scheffer, however, describes a process, which might be employed. The linen and cotton is to be steeped twenty-four hours in a cold solution of tin: it is then wrung, washed, and boiled a quarter of an hour with four-sixths of its weight of cochineal. The cotton takes a light red. These colours stand the sun, but not soap.

The difference of the processes to which recourse must be had for giving cotton and silk a scarlet colour, appears to me to be owing to the slight disposition these substances have for combining with the colouring matter of cochineal, or the compound of that colour and tin. Hence it follows, that this compound separates, unites in too large masses, and precipitates before its union with the stuff can take place. This inconvenience is prevented by first impregnating the stuff with solution of tin; because the oxyd of tin being combined with it, the colouring matter of the cochineal comes to fix in it, and then the compound can no longer precipitate.

Hence it appears, that this mode of operating ought to be tried, whenever we have reason to fear, that from the too feeble attraction of
2 the

the stuff, the compound which is to colour it, will precipitate before it can fix in it.

C H A P. VI.

Of Kermes.

KERMES (*coccus ilicis*, *Lin.*) is an insect found in many parts of Asia and the south of Europe. It was known to the ancients by the name of *coccum scarlatinum*, *coccus baptricus*, *coccus infectorius*, *granum tinctorium*. That which came from Galatia and Armenia was preferred; but at present it is gathered chiefly in Languedoc, Spain, and Portugal.

The kermes lives on a small kind of oak (*quercus coccifera*, *Lin.*) The females grow big, and at length remain motionless; when they are nearly the size and shape of a pea, and of a reddish brown colour. On account of their figure they were a long time taken for the seeds of the tree on which they live; whence

whence they were called *grains of kermes*: They also bore the name of vermillion.

The first who has spoken of them with any accuracy is Peter de Quiqueran, bishop of Senez, who mentions them in his book, *De Laudibus Provinciæ*, 1550.

The history of this insect may be seen in a memoir of Nissole, *Acad. des Sciences*, 1714, and more particularly in Reaumur's *Mémoires pour servir à l'Histoire des Insectes*, tom. iv.

Kermes has been supposed to have derived its name from an Arabic word, signifying a little worm, *vermiculus*; whence the name of *vermillion*, which also has been given it. Astruc derives the name from two Celtic words, one of which signifies *an oak*, the other *an acorn*^a.

The kermes fixes itself to the bark of the shrub on which it is found, by means of a cottony down which it is capable of furnishing. Mr. Chaptal has observed, that this down, like that of all the insects of this kind, has many characteristics of the caoutchouc: it is insoluble in alcohol, melts at the heat of boiling water, and burns with a flame on the

^a Mémoire pour servir à l'histoire naturelle du Languedoc.

coals. That learned chemist has given me the following description of the mode of gathering it in Languedoc.

“ About the middle of May they begin to
“ gather kermes, which is then arrived at its
“ ordinary size, and in colour and shape re-
“ sembles a small floe (prunelle). This harvest
“ generally continues to the middle of June,
“ and sometimes longer, if the great heats be
“ retarded, or no violent rains fall ; for one
“ heavy storm of rain is sufficient to put an
“ end to the gathering for that year.

“ In this occupation women are generally
“ employed. They set out early in the morn-
“ ing, with a lantern and a glazed earthen
“ pot, to pick off the kermes from the branches
“ with their fingers before day. This time
“ is the most favourable, 1st. Because the
“ leaves, which are prickly, are then less
“ troublesome, being softened by the morning
“ dew : 2^{dly}. Because the kermes weighs
“ more, whether because it is not dried by
“ the sun, or because it has parted with fewer
“ of its young, which are hatched by the
“ warmth. Some, however, are bold enough
“ to gather it in the day-time : but this is
“ rarely done.

“ A single

“ A single person may gather one or two
“ pounds a day.

“ At the beginning of the harvest, the kermes
“ weighs more, but fetches a less price than at
“ the end, when it is drier and lighter.

“ The price of fresh kermes varies also
“ according to the demand for it, and its
“ scarcity. It commonly sells for fifteen or
“ twenty sous a pound, at the beginning of
“ the gathering, and for thirty or forty to-
“ wards the end.

“ The buyers are obliged as soon as possible
“ to stop the progress of the eggs, in order
“ to prevent the young contained in the shell
“ from getting out. This shell is nothing but
“ the body of the mother, distended by the
“ growth of the eggs. The female has no
“ wings : it settles itself on a leaf, where it
“ fixes : the male comes to fecundate it : and
“ it afterwards increases in size merely from
“ the growth of the eggs. To kill the young
“ contained in these, the kermes is steeped
“ ten or twelve hours in vinegar, or exposed
“ to the steam of vinegar, which requires less
“ time, as half an hour is sufficient. It is
“ afterwards dried on linen cloths. This
“ operation gives it a colour like that of red
“ wine.”

If

If the living insect be bruised, it gives out a red colour. Its smell is somewhat pleasant : its taste a little bitter, rough, and pungent. When dry it imparts this smell and taste to water, and also to alcohol, to both of which it gives a deep red colour. This colour is retained by the extracts made from these infusions.

To dye spun worsted with kermes, it is first boiled half an hour in water with bran ; then two hours, in a fresh bath, with one fifth of Roman alum, and one tenth of tartar, to which *four water* is commonly added ; after which it is taken out, tied up in a linen bag, and carried to a cool place, where it is left some days. To obtain a full colour, as much kermes as equals three fourths, or even the whole of the weight of the wool, is put into a warm bath, and the wool is put in at the first boiling. As cloth is more dense than wool, either spun or in the fleece, it requires one fourth less of the salts in the boiling, and of kermes in the bath. Less proportions of kermes will produce lighter and paler colours. If we want a succession of shades, we must, as usual, begin with the deepest.

Hellot directs a small handful of cot or refuse wool to be thrown into the boiler in

which the kermes is, and to let it boil a moment, before the wool to be dyed is put in. This will absorb a kind of black dregs, and the wool afterwards dipped, will take a better colour. Before the wool that is just dyed is taken to the river, it may be dipped in a bath of water a little warm, in which a small quantity of soap has been dissolved. In this way the colour will acquire more brightness, though it will be rendered a little rosy, that is, will have a crimson cast.

By using kermes and tartar, without alum, and with as much solution of tin as is required for a scarlet with cochineal, Hellot obtained a very lively cinnamon colour in a single bath. Cloth steeped in a solution of sulphat of potash, took with kermes a pretty fine and permanent agate gray : in a solution of sulphat of soda, a dirty gray of little durability : in a solution of sulphat of iron and tartar, a fine gray : in a solution of tartar and sulphat of copper, an orange colour : and the same with nitrat of copper. Solution of bismuth added drop by drop to a kermes bath, produced a violet. All acids convert it to a cinnamon colour, which inclines more or less to red, according as the acids are weak, and their quantity

quantity small. Alkalis render its colour dull and rosy.

The colour that kermes imparts to wool has much less bloom than the scarlet made with cochineal, whence the latter has generally been preferred, since the art of heightening its colour by means of solution of tin has been known. The former however, is more permanent ; and spots of grease may be discharged from it without injury. It is a blood-red, and is still to be seen unchanged in old tapestry. The scarlet made by kermes was called *scarlet in grain*, because that insect was supposed to be a grain: it was also called venetian scarlet, because its chief manufactory was in the city of Venice.

Solution of tin has been tried with kermes as well as with cochineal ; and Scheffer describes several processes for dyeing in this way : but the colour always inclines to yellow or cinnamon, because the compound formed of its colouring matter and the oxyd of tin, retains a yellow hue, from the action of the acid, as does the colouring matter of madder.

The permanency of the colour of kermes has frequently made it be regretted, that our dyers have relinquished the use of it, as they

at present employ very little. Some mix a small quantity with cochineal ; and this has been observed to give a greater body (*plus de fond*) to the colour, but it diminishes its bloom. The greater part of the kermes we have comes from the Levant.

No one has yet been able to give silk any thing more than a dull reddish colour with kermes.

Scarlet, for which half kermes and half madder is used, is called scarlet in *half grain*. This mixture gives a very permanent dye ; but it is not lively, and inclines a little to the blood-colour. The turbans manufactured at Orleans for the Levant, are said to be dyed in this manner : though probably a little brasil-wood is added.

The *coccus polonicus* is a small round insect, found adhering to the roots of a species of polygonum (*scleranthus perennis*). It is gathered in some parts of Poland, towards the end of June. Its properties appear to resemble those of kermes ; but no use is made of it in Europe. It is sold to the Turkish and Armenian merchants ; and is used in Turkey, for dyeing wool, silk, and horse-hair : the women also use it to colour their nails.

There

There are many other insects which also afford a red colour ; and some of them have been employed for that purpose : but from the advantages offered by cochineal, they have fallen into neglect or disuse.

C H A P. VII.

Of Lac, or Gum-Lac.

LAC is a substance of a colour more or less red ; it is brought to us from the East-Indies in different forms. This substance is analogous to that of the combs of bees, and constructed by a species of winged ants, generally on the small branches of the *croton lacciferum*.

Geoffroy, who has published some interesting observations on this subject^a, considers it as a true wax, indebted for its colour to the embryos of the insects, which have formed

Mém. de l'acad. 1714.

alveoli in it which are nearly of a round shape ; so that the name of a gum is highly improper.

Many sorts of lac are distinguished ; the principal of which are : 1st. Stick-lac. This is what the ants construct around the little branches or twigs which the inhabitants take care to plant as supports to their work. It is the most rich in colour : though there is some of it at Madagascar nearly colourless. 2d. Seed-lac. This is less coloured than the preceding sort. 3d. Shell-lac. This is brought to us in thin plates, differing in size and in transparency. It has generally a dirty colour, and is mixed with wood and earth. There is some reason to believe, that its colouring matter has already been extracted by the Indians.

The second and third sorts are used for making sealing wax, colouring it for red wax with minium, for black with lamp-black, for aventurine or gold-colour with orpiment, &c. Geoffroy says, that lac, separated from the little bodies it contains, yielded him, on distillation, the same products as wax ; and the small bodies, which are reducible to a fine red powder, the products of animal substances. The colouring matter, which arises from these
little

little bodies, supposed by him to be chrysalides, is soluble both in water and alcohol, and gives them a fine red colour.

For dyeing, stick-lac of the deepest colour should be chosen. It is to be separated from the sticks and powdered.

The colour obtained by means of lac has not the bloom of scarlet made with cochineal, but has the advantage of being more permanent. It may be employed to good purpose, by mixing a certain quantity with cochineal, when, if it be not in too large proportion, the scarlet will be rendered more permanent, without losing any thing of its beauty.

To separate the part soluble in water, and calculate its proportion to the wax or resin, Hellot used to extract it by means of water and mucilage of comfrey, to precipitate the colouring matter with alum, and to collect and dry this precipitate, the weight of which was only one fifth of the lac. This precipitate is a compound of the colouring matter and alumine or the base of alum: and this he used for dyeing.

Lac may be used in a more simple manner. Nothing more is necessary than to boil the cochineal and solution of tin for a proper

length of time; after which the bath is to be cooled, and the lac put in, in powder. It requires a very moderate heat, otherwise it will dye very unequally; and also a greater proportion of solution of tin than cochineal. The cloth ought to be washed very hot at coming out of the boiler, because the resinous particles fixed in it are difficult to separate when cold. Lac may be used with success for *soupe au vin* colour, putting it into the boiling, in which there must be no alum, as that would precipitate its colouring matter too quickly. Cochineal is to be used in the reddening, and it is to be faddened in the usual manner.

According to Hellot, fixed alkali or lime-water changes the bright red produced by lac to the colour of wine lees, and the muriat of ammoniac gives it a cinnamon colour, or light marrone, according as there is more or less of that salt.

Geoffroy conjectures, that lac is used for dyeing the red morocco of the Levant, after it has undergone a suitable preparation. It appears, in fact, that lac is used with cochineal for this purpose at Diarbekir, and that at Nicosia they use kermes. Mr. Quemiset asserts,

ferts, that kermes, lac, or cochineal, may be used indifferently ^b.

What appears to give lac the superiority over kermes, is, that it is able to bear the action of solution of tin, and experiences the good effects of it, without its colour being changed to yellow ; and it even requires, as has been seen, a greater proportion of it than cochineal.

C H A P. VIII.

Of Archil.

THE archil used in dyeing is in the form of a paste, and of a red violet colour. Two sorts are chiefly distinguished ; herb, or Canary archil ; and ground (de terre) or Auvergne archil, which is also called pérelle. The first, which is most valued, is prepared from a species of lichen (*lichen rocella*) which

L'art d'apprêter & de teindre toutes sortes de Peaux.

grows

grows at Cape-Verd, and the Canary islands, on the rocks near the sea : the second is made from a lichen (*lichen parellus*) that grows on the rocks of Auvergne.

Micheli, as quoted by Hellot, says, that the workmen who prepare archil at Florence, reduce the plant to a fine powder, which they pass through a sieve, and afterwards moisten slightly with stale urine : this mixture they stir once a day, adding each time a certain proportion of powdered soda, till it has acquired a dove colour : they then put it into a wooden cask, and add urine, or lime water, or solution of gypsum, sufficient to cover it ; and keep it in this state. In the description given in Plietho, sal ammoniac, sal gem, and saltpetre, are added in the preparation : but Hellot is convinced from experience, that lime and urine are the only ingredients necessary ; and that the mixture must be frequently stirred, adding at the same time fresh quantities of these. It is proper at the end of the process, to let the volatile alkali which has formed evaporate, that the archil may have the violet smell of that which is well prepared. To preserve it any length of time however, it must be kept moistened with urine.

Kalm says, in an appendix to a memoir of Linnæus in the Stockholm transactions for 1745, that two lichens, which he describes, are used in some parts of Sweden for dyeing red; and it is also said, in the same transactions for 1744, that there is a species of lichen found in Sweden (*lichen foliaceus umbilicatus subtus lacunosus*, Lin. Flor. Suec.) which, being prepared with urine, dyes wool and silk a fine and permanent red or violet.

There are perhaps many other species of moss and lichen, which might be useful in dyeing, if they were prepared in the same manner as archil. Hellot gives the following method of discovering whether they possess this property, or not. A little of the plant is to be put into a glass vessel, and moistened with ammoniac and an equal quantity of lime-water, adding a little muriatic ammoniac or sal ammoniac: the phial is then to be corked. In three or four days, if the plant be of a nature to afford a red colour, the little liquor which can be poured off will be tinged of a crimson red, as will also the plant itself. If the liquor or the plant, do not assume that colour, nothing is to be expected from it, and it would be useless to attempt its preparation in the large way. Lewis however says, that
he

he has tried a great number of mosses in this way, and that the greater part afforded him a yellow or reddish brown colour, whilst a very few gave him a deep red liquor, that communicated only a yellowish red to cloth ^a.

Prepared archil readily gives out its colour to water, volatile alkali, and alcohol. Its solution in the latter is used for making thermometers with spirits: and when these thermometers are thoroughly deprived of air, the liquor loses its colour in a few years, as Nollet has observed ^b. The contact of air restores the colour; which is again destroyed in vacuo by time. The aqueous infusion loses its colour in a few days, if deprived of air: a singular phenomenon, which merits further inquiry.

The infusion of archil is of a crimson inclining to violet. Acids give it a red colour: but, as it contains ammoniac, by which its natural colour has been already modified, fixed alkalis produce little change in it, only rendering its colour somewhat deeper, and more inclined to violet. Alum forms with it a dark red precipitate: and the supernatant liquor retains

^a The works of Caspar Neumann.

^b Mém. de l'acad. 1742.

a yellowish red colour. Solution of tin produces a reddish precipitate, which falls down very slowly; the supernatant liquor retains a slight red tinge. Metallic salts produce with it precipitates which exhibit nothing remarkable.

The aqueous solution of archil applied to cold marble, penetrates it, and imparts to it a fine violet colour, or blue inclining to purple, which resists the action of the air much longer than colours communicated by archil to other substances. Dufay says, that he has seen marble stained with this colour unaltered at the end of two years.

To dye with archil, the quantity judged necessary, according to the quantity of wool or stuff to be dyed, and the shade to be given it, is mixed in a bath beginning to grow warm. The bath is then heated till it is ready to boil, and the wool or stuff is dipped in it, without any other preparation, keeping that in longest, which is to be of the deepest shade. A beautiful gridelin inclining to violet is thus obtained, but the colour has no permanency; so that archil is rarely used, except for modifying, heightening, or giving bloom to other colours. Hellot says, that having applied archil on wool boiled with alum and tartar, the

the colour did not stand the air any better than when the wool had undergone no preparation. But he obtained a much more permanent colour from the herb archil, by putting a little solution of tin into the bath. This changes the natural colour of the archil to one more or less approaching to scarlet, according to the quantity of the solution employed. This process is to be conducted nearly in the same manner as that for dyeing scarlet, except that it requires only one bath.

According to Mr. Poerner, one pound of wet cloth, boiled for about an hour in a bath composed of ten ounces of archil and an ounce and a half of tartar, acquires a bluish red colour. If previously prepared with tartar and solution of tin, it assumes an amaranth colour: and if prepared with alum, a paler and less lively colour than the foregoing.

Archil is frequently used for deepening different shades, and giving them a bloom. It is thus used for violets, lilacs, mallow, and rosemary flower colours (*mauve*, *fleur de ro-marin*).

To obtain a deeper tint, alkali, and *cremor calcis* (*lait de chaux*) diffused in water, are sometimes added to it as for deep *soupe au-vin* colours. The remainder of this liquor will

will give beautiful agate, rosemary flower, and other delicate colours, which cannot be procured equally fine by any other means. Alum cannot be employed instead of this substance for deepening colours, as it does not afford the same bloom, and tarnishes the colour.

Herb archil is superior to that of Auvergne, as it communicates a greater bloom, and abounds more in colouring matter. It has the advantage too, of bearing to be boiled: and the latter cannot be mixed with alum, as it destroys its colour. The herb archil however, has the inconvenience of dyeing unequally, at least if the cloth be not passed through hot water the instant it comes out of the dye.

Archil is never employed alone for dyeing silk, unless for lilacs: but silk is frequently dipped in an archil bath, either before or after dyeing in others, to modify various colours, and give them a bloom. Many instances of this will be given in treating of compound colours: here I shall mention only the manner of treating white silks with the archil bath. The same process is employed, in a bath more or less charged with this substance, for silks already dyed.

A quantity

A quantity of archil proportionate to the colour required, is boiled in a proper vessel. The clear liquor is then poured quite hot, leaving the dregs at the bottom of the boiler, into a trough of a convenient size, in which the silk, carefully cleansed from soap, is to be turned with great care, till it has acquired the proper shade. The silk is then to be beetled once at the river.

Archil is a substance of great use in dyeing: but as it is rich in colour, and communicates a seducing bloom, dyers are frequently tempted to make an improper use of it, and to go beyond those proportions which would add to the beauty of colours, without any great injury to their permanency. The colour, however, obtained from it by means of solution of tin, which is red, and approaches to scarlet, is less fugitive, than those in which that ingredient is not employed. This solution appears to be the only thing capable of increasing its durability. It may be employed not only in the dye-bath, but in the preparation of the silk, when by mixing archil with other colouring substances, bright colours sufficiently permanent may be obtained.

C H A P. IX.

Of Carthamus.

CARTHAMUS, or bastard saffron (*carthamus tinctorius*) of which the flower only is used in dyeing, is an annual plant, cultivated in Spain, Egypt, and the Levant. There are two varieties of it; one with larger leaves, the other with smaller. The latter is said to be that of Egypt; where it makes a considerable article of trade.

Carthamus was formerly cultivated in Thuringia and Alfatia; but the preference given to that of the Levant has occasioned its culture to be nearly abandoned in our climates. The celebrated Beckmann, who has published a very interesting dissertation on carthamus^a, has endeavoured to discover the difference between that produced with us, and that brought from the Levant: but previous to relating his observations, it will not be amiss to give an account of the properties of this substance, such as it is employed in dyeing.

^a Comment. Societat. Gotting. tom. iv. 1774.

Carthamus contains two kinds of colouring matter; the one, yellow; the other, red. The first alone is soluble in water: its solution is always turbid: with reagents it exhibits the appearances commonly observed in yellow colouring matter: acids render it lighter, alkalis make it deeper, and more approaching to orange: both produce a small portion of a fawn-coloured precipitate, by means of which it becomes clearer. Alum forms with it a deep yellow precipitate in small quantity: solution of tin, and other metallic solutions, precipitates which have nothing remarkable.

Alcohol acquires but a slight tincture from the flowers, after all the yellow substance has been extracted by repeated washings. If these flowers be put into a solution of caustic alkali, they become yellow, and the liquor which is pressed out is of a deep yellow colour. On saturating the alkali with an acid, the liquor becomes turbid, reddish, and gradually deposits a very small quantity of a reddish yellow precipitate. With solutions of alum, zinc, and tin, a yellow precipitate is formed; and with solutions of iron and copper, a precipitate inclining to green. If instead of a solution of caustic alkali, a solution of carbonat of alkali be used, acids produce with it a more copious precipitate

precipitate of a redder hue: but the redness differs according to the acid employed. Alum also produces with the latter alkaline solution, a red precipitate, which is so light, that it generally swims on the surface of the liquor. This colouring matter is so delicate, and so easily changed, that if heat be employed to dissolve it, the precipitates produced by acids will not have so fine a colour.

Mr. Beckmann has observed, that the carthamus of Thuringia contained much more of the yellow matter, than that of the Levant: that in other respects the red matter of the former was by no means inferior in beauty to that obtained from the latter: yet, that to produce equal effects, half as much more of it was required. He next examined, whether this difference depended on the climate, or only on the mode of preparation.

Hasselquist relates, in his travels in Egypt, that when the flowers of carthamus are gathered, they are pressed between two stones, to squeeze out the juice. After this they are washed several times with water, which in Egypt is naturally salt. When taken out of the water they are pressed between the hands, and then spread on mats, placed on the flat roofs of their houses; where they are covered in the day time, that

the sun may not dry them too fast, but left exposed to the dew at night. They are occasionally turned, and when sufficiently dry, taken in, and kept for sale under the name of *saffranon*.

If the carthamus of the Levant, such as it is in commerce, be compared with that of Thuringia, the former will be found to be more pure, a little moist, and in compressed masses; the latter, drier and more elastic. These differences depend on the preparation. Writers on agriculture, deceived by the erroneous name of *bastard saffron* given to carthamus, have supposed, that it should be treated like saffron. Hence they direct it to be gathered in a dry season, and dried with care. Mr. Beckmann thinks on the contrary, that the mode adopted in Egypt ought to be imitated. He advises even to add a little salt to the water used in preparing it, to give it the quality it has naturally in Egypt.

The flower of carthamus has a fine colour of fire, but in drying it grows yellow. It should not be gathered till it grows dry; and it is better, if it has been rained upon in that state, though the contrary opinion is erroneously held. The want of rain may be supplied by watering the flowers morning and evening. When they

they are gathered, the seeds may still be left to ripen.

The intention of these directions is, to promote the separation of the yellow matter, the abundance of which constitutes the difference between the carthamus of our climates, and that of the Levant. Carthamus should be kept in a moist place, as its becoming too dry would be injurious.

There are many reasons to induce us to enrich our agriculture with this production. The seeds of carthamus are very good food for wild fowl, and particularly for parrots, whence they have received the name of grain de perroquet. An useful oil might be expressed from them, and the residue given to cattle. The dry leaves and stalks would serve as fodder for sheep and goats in the winter; and those stalks which are too large might be used as fuel, after they had stripped them. Mr. Beckmann has found the carthamus ripen well at Gottingen, where the soil is sandy. The ground should be moderately dunged; and the plant neither transplanted nor watered.

No use is made of the yellow substance of carthamus: but to extract that part, it is put into a bag and trodden in water, till no more colour can be pressed out. The flowers, which

were yellow, become reddish in this operation, and lose nearly half their weight: it is in this state they are used.

The yellow substance might however be employed: and Mr. Poerner has made many experiments on the subject^b. The principal results of his experiments were, that wool, without any preparation, takes from it a yellow colour, which is not permanent; but that which it takes after having been prepared with alum and tartar, though not very lasting, is better. Mr. Beckmann asserts, that cloth prepared with tartar, or with tartar and alum, acquires from it a good yellow colour; and that carthamus contains more yellow colouring matter than an equal weight of fustic itself.

To extract the red part of carthamus, and afterwards apply it on the stuff, recourse is had to the property alkalis possess of dissolving it, and it is precipitated by means of an acid. It has been found, that lemon-juice produces the finest colour. Mr. Beckmann says, that next to this, the sulphuric acid produces the best effect, provided a proper quantity only be used: too much of it would alter and destroy the co-

^b *Chemische Versuche und Bemerkungen zum Nutzen der Farbekunst; dritter Theil.*

lour. According to Scheffer, the juice of the berries of the service tree (*forbus aucupatorius*) may be substituted for lemon-juice. It is thus prepared. The berries are bruised in a mortar with a wooden pestle, and the expressed juice is left to ferment: it is then bottled, and the clear part, which is most acid, becomes fitter for use the longer it is kept. This operation requires some months, and should be undertaken only in summer.

It has been seen, that the process consists in extracting the red colouring matter by means of an alkali, and precipitating it with an acid. From this precipitate is procured the *rouge* used by ladies. To make it, the solution of carthamus is prepared with crystals of soda, and precipitated by lemon-juice, which has stood some days to settle. It has been remarked, that lemons beginning to decay were fitter for this purpose than those less ripe, the juice of which retains much mucilage. The precipitate of carthamus is dried on plates of delft with a gentle heat: from these it is separated, and ground very accurately with talc, previously reduced to a very subtile powder by means of the leaves of shave-grass, and passed successively through sieves of different degrees of fineness. The fineness of the talc, and its

proportion to the precipitate of carthamus, make the difference between the cheaper and dearer rouges.

Wool may be dyed red by means of carthamus, as Mr. Beckmann has experienced; but this red soon changes towards an orange: and as the finest and most various reds may be obtained from cochineal, which are at the same time much more permanent than those of carthamus, the use of the latter for wool is relinquished.

Carthamus is used for dyeing silk poppy colour, a bright orange red (nacarat) cherry, rose, and flesh colour. The processes differ according to the intensity of the colour to be given, and the degree in which it approaches that of fire: but the carthamus bath, which varies in the mode of using, is prepared as follows:

After having extracted the yellow matter of the carthamus, and opened the cakes, it is put into a deal trough, where it is sprinkled at different times with *cendres gravelées*, or soda, the latter of which is best, well powdered and sifted, in the proportion of six pounds to a hundred; mixing it well as the alkali is put in. This operation is called *amestrer*. The carthamus thus mixed with the alkali, is put into a small
2 trough

trough with a grated bottom, first lining it with a closely woven cloth. When this trough is nearly half filled, it is placed upon the large one, and cold water is poured on it till the lower trough is full. The carthamus is then set over another trough, till the water comes from it almost colourless. A little more alkali is then added, and fresh water is poured on. These operations are repeated, till the carthamus is exhausted, and become yellow.

The filk being distributed on the rods in hanks, lemon-juice, which comes from Provence in casks, is poured into the bath, till it is of a fine cherry colour. This is called *turning* (virer) the bath. Having stirred the bath well, the filk is dipped in, and turned on the skein sticks as long as it appears to get any colour. For poppy colour, it is taken out, wrung, drained on the pegs, and passed through a new bath, where it is treated as in the former. It is then dried, and passed through fresh baths, washing and drying it after every operation, till it has obtained the depth of colour required. When it is at the proper point, it is brightened, by turning it seven or eight times in a bath of hot water, to every bucket of which about a gallon of lemon-juice is to be added.

When

When silk is to be dyed poppy or fire colour, it must be first scoured as for white; and must then have a flight annotta ground, in the manner that will be mentioned when treating of that substance. This silk ought not to be alumed.

Bright orange reds and deep cherry colours are treated exactly in the same way as poppy colour, except that they have not the annotta ground, and that they may be dipped in the baths that have been already used for poppy colour, which will exhaust them. Fresh baths are never made for these colours, unless the dyer have no occasion for a poppy.

The lighter cherry colours, rose colours of every shade, and flesh colours, are made from baths of the second and third runnings of the carthamus, which are weaker than the first. In these the deepest shades are first dipped.

The lightest of all these shades, which is a very pale flesh colour, requires a little soap to be put into the bath: this softens the colour, and prevents it from taking too quickly or unevenly. The silk is then washed, and brightened a little in the bath which has been used for brightening the deeper colours.

All these baths are used as soon as they are made, and as quickly as possible, as by keeping, they lose much of their colour, which would

even be entirely lost after a time. They are also used cold, because the red feculæ lose their colour on being exposed to heat. The reader must have observed, that in the experiments I have described, caustic alkalis attack the delicate colour of carthamus, and turn it yellow: on this account crystals of soda should be preferred to any other alkali. At least we should choose one that contains most carbonic acid, as salt of tartar.

To lessen the expence of carthamus, it is usual, for deep shades, to mix with the first and second bath about a fifth of the bath of archil.

When raw silk is to be dyed, that which is very white should be chosen, and treated as boiled silk, with this difference only, that the poppy colours, bright orange reds, and cherry colours, are passed through baths that have been used for the same colours for scoured silk, because the raw silk in general takes colours more readily.

Poppy colour prepared in an acid liquor resists the action of vinegar, but it soon changes and fades in the air. Scheffer says, that when he used the juice of services instead of lemon-juice, the colour stood somewhat longer.

Mr. Beckmann has made some experiments on applying the red colour of carthamus to cotton*. Having macerated cotton two hours in melted lard, he washed it well, and dyed it in the common way with carthamus deprived of its yellow matter. This cotton took a deeper colour than some which had undergone no preparation. Soap succeeded equally well; and olive oil still better. Mr. Beckmann then dipped his cotton in oil repeatedly, drying it each time. After the last drying he washed and dried it; and then passed it through the yellow bath of carthamus, to which he added galls and alum. Finally, he dyed it with the alkaline solution of carthamus and lemon-juice. By these means he obtained a fine full red. Cotton treated in the same manner, without having been impregnated with oil, took a colour of the same kind, but less full, and less capable of standing the action of the air. From these experiments, he thinks, that cotton to be dyed with carthamus should receive a preparation similar to that given it for the Adrianople red.

To dye cotton poppy colour, Mr. Wilson directs the carthamus, thoroughly freed from the

* Exper. Lina xyliua tingendi Flor. Carth. tinct. Comment. Soc. Reg. Gotting. vol. iii. 1780.

yellow colouring matter, to be put into a vessel, at the bottom of which is a hair sieve, and to pour on it a solution of pearl-ashes, mixing them well, and leaving them to stand all night. The next morning the liquor is to be drawn off by a cock at the bottom of the vessel, and the cotton to be dyed is to be put into it, and turned by means of a winch. In the meantime a solution of tartar is prepared, and left to settle, and whilst it is yet hot, it is poured into the carthamus bath, till the liquor is rendered a little sour. The cotton must continue to be turned in this, till it has acquired the proper shade. It is then washed lightly, and dried in a stove. In this way it obtains a fine colour.

To give cotton a scarlet, it must first be dyed yellow, in the manner directed under the article annotta, and whilst yet wet, must be dyed with carthamus, in the manner just described. It thus acquires a fine scarlet; but it is not permanent, and will not stand washing.

C H A P. X.

Of Brasil-Wood.

THIS wood, which is of extensive use in dyeing, derives its name from that part of America from which it was first imported. It bears also the names of Fernambucca, wood of St. Martha; of Japan, and of Sapan, according to the place where it was produced. At present it is cultivated in the Isle of France, where it is naturalized. That of the Antilles, called *brasiletto*, is least esteemed.

Linnæus describes the tree that furnishes brasil-wood by the name of *cæsalpinia crista*: that which gives the japan or sapan-wood, distinguished into large and small sapan-wood, by the name of *cæsalpinia sappan*: and that from which we have the *brasiletto* he calls *cæsalpinia vesicaria*.

This tree grows generally in dry places, and amidst rocks. Its trunk is large, crooked, and knotty. The flowers of the *cæsalpinia sappan* and *cæsalpinia vesicaria* have ten stamina; those of the true brasil-wood, only five.

That

That which comes from Fernambucca is most valued.

Brazil-wood is very hard, and susceptible of a fine polish. It sinks in water. It is pale when cut, but reddens on exposure to the air; having different shades of red and orange colour. Its goodness is distinguished chiefly by its weight. When chewed, it has a sweetish taste. It may be easily distinguished from red sanders, because the latter does not give out its colour to water.

Boiling water takes the whole of the colouring matter from brazil-wood, and becomes of a fine red, if the boiling be continued long enough. From the residuum, which appears black, much colouring matter may still be extracted by means of alkalis. The solution in spirit of wine, and that in volatile alkali, are deeper than the preceding. According to Dufay, a tincture of brazil-wood in alcohol will give hot marble a red colour, which changes to a violet. If the marble thus stained be covered with wax, and the heat increased, the colour will pass through the different shades of brown, till it arrives at a chocolate.

Fresh decoction of brazil-wood yields, by the addition of sulphuric acid, a small quantity of
a red

a red precipitate inclining to fawn-colour : the liquor remains yellow and transparent. Nitric acid renders the liquor yellow at first : but if more be added, the liquor acquires a deep orange colour, and becomes transparent, after having deposited a precipitate nearly resembling the former in colour, but more abundant. Muriatic acid acts on it like the sulphuric. The oxalic acid produces a precipitate of an orange red, nearly as copious as the nitric acid does : the liquor remains transparent, and of the same colour as in the former trials. Distilled vinegar gives a very little precipitate of the same colour ; the liquor remaining transparent, and a little more inclining to orange. Tartar furnishes still less precipitate, and leaves the liquor turbid, and redder than in the preceding instance. Fixed alkali restores the decoction to a crimson, or deep violet, inclining to brown ; and produces a scarcely perceptible precipitate of the same colour. Ammoniac gives a brighter purple, or violet, and a little precipitate of a fine purple. Alum occasions a red precipitate, inclining to crimson, copious, and subsiding slowly : the supernatant liquor retains a fine red colour, similar to that of the fresh decoction : this liquor also affords a copious precipitate,

precipitate, on saturating the acid of the alum with an alkali. In this manner an inferior sort of carmine is prepared, and also a liquid lake for miniature painting. Alum and tartar produce a little brownish red precipitate; the liquor remaining very clear, and of an orange red. Sulphat of iron causes the tincture to assume a black colour, inclining to violet: the precipitate that falls down is abundant, and of the same colour, as is also the liquor that swims above it. Sulphat of copper likewise produces a great deal of precipitate, the colour of which is darker: the liquor remains transparent, and of a brownish red. Sulphat of zinc gives a brown precipitate, small in quantity, leaving the liquor transparent, and of the colour of pale beer. A solution of acetite of lead occasions a copious precipitate, of a pretty fine deep red: the liquor is of an orange red and transparent. Solution of tin in the nitro-muriatic acid gives a very abundant precipitate of a fine rose colour: the liquor remains transparent, and perfectly colourless. Finally, with corrosive sublimate a light precipitate of a brown colour is obtained; the liquor remaining transparent, and of a fine yellow.

In the *Journal de Physique*, for February 1785, are some curious experiments on the action exerted by acids on the colour of brazil-wood. If, after having changed it yellow by means of tartar and acetous acid, the nitro-muriatic solution of tin be poured in, a very copious rose-coloured precipitate is immediately formed. If to the solution rendered yellow by an acid, a greater quantity of that acid, or an acid more powerful be added, the red colour will be restored. The sulphuric acid is best calculated to produce this effect. Some salts also restore the red colour of brazil-wood, which has been destroyed by the action of acids.

It has been remarked that the decoction of brazil-wood, called *juice* of brazil, is less proper for dyeing when fresh, than when it is old, or has even undergone fermentation. By keeping, it acquires a yellowish red colour. Hellot recommends the hardest water than can be had to be used for making this decoction: but it is necessary to observe, that such water deepens the colour by means of the earthy salts it contains. Having boiled the wood reduced into chips for three hours; the liquor is poured into a cask, fresh water is added to the brazil, it is boiled three hours longer, and
this

this liquor is added to the former. When brasil-wood is used in a dye-bath or flat, it is proper to enclose it in a thin linen bag, as it is all colouring woods.

Wool dipped in the brasil-juice would acquire only a slight tint, that would soon fade : it is necessary therefore, that it should undergo certain preparations.

The wool is to be boiled in a solution of alum, to which a fourth of its weight, or even less, of tartar has been added. A greater proportion of tartar would render the colour yellow. The wool thus impregnated is to be kept at least a week in a cool place ; after which it is dyed by boiling gently in the brasil-juice. The colouring matter which is first deposited does not yield so fine a colour : it is proper therefore, to dip the coarsest stuff in the bath first. In this manner a bright red is obtained, which stands the action of the air tolerably well.

If the red colour of brasil-juice be destroyed by means of any acid, it will give woollens a more or less deep dun colour, which is very permanent.

Mr. Poerner prepares the cloth with a boiling composed of solution of tin, alum, and a little tartar ; and makes his bath with brasil-

wood, and a considerable proportion of alum. In the residuum of this bath he dyes a second piece, which has received a similar preparation. The first piece takes a fine brick colour; the second, a colour that approaches scarlet^a. The shades may be greatly varied by varying the proportions of the ingredients.

Colours obtained from brasil may thus be rendered tolerably permanent: yet they are not comparable in this respect, to those obtained from cochineal, or madder. A bloom is sometimes given to colours produced from the latter substance, by passing the cloth dyed with it through the brasil-juice: but this bloom soon vanishes.

Mr. Gühliche gives a process, by which he pretends finer and more permanent colours are obtained, than by those in use. He directs pure vinegar, or aceto-citric acid^b, or
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^a Instruction sur l'art de la teinture.

^b I give the appellation of *aceto-citric acid* to a liquor of which Mr. Gühliche makes great use in dyeing, under the name of vegetable acid spirit, which he prepares in the following manner.

He takes any quantity of lemons, those of which the rind is rotten will do, removes the peel, and the skin that adheres to it, and slices them into a vessel, which should not be made of wood. He then sprinkles them with a
quantity

aqua regia, to be poured on brasil-wood, reduced to a powder, or very small chips, till it is covered with the liquor, or even till the liquor is a certain height above it ; the mixture to be well shaken, and then left to settle for twenty-four hours : after which it is to be decanted, filtered, and kept for use. On the residuum, a vegetable acid, or pure water, is to be poured, and having stood a day or two, filtered. This is to be repeated till all the colouring matter is extracted, when the wood will be found to be black. All these liquors are to be mixed together.

The stuff having been prepared with a slight galling of sumach, or white galls, is slightly

quantity of good vinegar, which he thinks comes near that of the lemon-juice, squeezes out the liquor through a flannel, by means of a press, and filters the expressed liquor through paper. It may be used with success in this state ; but it is apt to grow mouldy, and the acid is watery. In order that it may keep therefore, and not dilute the baths into which it is put, he directs it to be purified and concentrated as follows : The liquor is to be exposed to the sun, till a sediment forms, and it grows clear. It is then to be filtered, and distilled in a sand-bath. The receiver is to be changed when the liquor that drops becomes acid, and the distillation continued till oily streaks are perceptible in the neck of the retort. The acid found in the receiver is to be kept for use.

alumed : being just rinsed, it is put quite wet into a bath prepared as follows :

Some of the acid solution of brasil-wood is diluted with a quantity of water proportionate to the quantity of the stuff, and the depth of the colour to be given it. When this is so hot that the hand will just bear it, solution of tin is poured in, till it is of a fire colour : it is then stirred and the stuff is put in. After this has remained in half an hour, it is taken out and washed. The remainder of the bath may be used for lighter shades : but those stuffs only must be galled that are for deep ones.

Brazil-wood is used for dyeing silk what is called *false* crimson, to distinguish it from that produced by means of cochineal, which is far more permanent.

The silk should be boiled with soap, in the proportion of twenty pounds of the latter to a hundred of the former, and afterwards alumed. Less aluming is required for this than for grain crimson. Having refreshed it at the river, it is dipped in a bath, more or less charged with brasil-juice according to the shade to be given. If water containing no earthy salt be employed; the colour will be too red for crimson; to remedy which, the silk may be passed through a slight alkaline solution, or a little alkali may be

be added to the bath. Washing the filk in hard water, till it has acquired the proper hue, will answer the same purpose.

To make false crimsons deeper, or dark reds, juice of logwood is added to the brasil bath, after the filk has been impregnated with the latter. A little alkali may also be put in according to the shade to be obtained.

To imitate poppy or fire colour, the filk must have an annotta ground, even deeper than when it is to be dyed with carthamus: after which it is washed, alumed, and dyed with the brasil-juice, to which a little soap-suds is commonly added.

Solution of tin cannot be used for dyeing filk with the juice of brasil-wood, as with cochineal; and the reason in both is the same: the colouring particles would separate too quickly to be capable of fixing on the filk, which does not attract them so powerfully as wool. But as Bergman remarks, in his notes on Scheffer^c, the colours imparted by dye woods may be much improved by steeping the filk in a cold solution of tin. A strong decoction of brasil-wood, says he, gives yellow filk a scarlet colour, inferior indeed to

^c Essai sur l'art de la teinture,

that given by cochineal, but finer and more permanent than if it be steeped in alum only, and as capable of standing the proof by vinegar, as crimson or poppy in grain. It is necessary, instead of using raw silk, to give a yellow ground to silk that has been scoured, or to mix some yellow substance with the brasil-juice. Of late many artists have turned their attention to this process, and have produced various effects by applying it to different colouring substances, which of themselves afford colours of little durability, either employing them alone, or mixed in various ways.

Mr. Gubiche however, describes a process in which he uses solution of tin immediately, to give silk a fire colour. He directs the silk to be galled with a solution of galls in white wine, asserting, that an astringent solution thus made preserves the brightness required in silks, much better than one prepared with water. With this solution he mixes water, till it has acquired a yellow colour; and impregnates the silk well with it, leaving it to steep in it cold for twelve hours. He then presses out the liquor strongly, but without washing the silk, which he dries, and afterwards soaks for twelve hours in a solution of alum, containing

taining four ounces for every pound of silk. The silk, taken out of the alum water, is wrung, and put while wet into a bath, prepared as above directed, after adding to it an ounce of solution of tin. The remainder of the bath may be exhausted for lighter shades. If the fire colour be required more approaching to orange, the silk is not to be galled, but to be alumed cold, with two ounces of alum to the pound of silk : after which it must be dyed orange colour with annotta, without boiling, and before it dries, dyed in the bath of brasil-wood above described. The author confesses, that these colours, particularly the latter, are not very permanent. For rose colours he omits the galling, and for the aluming uses only two ounces of alum. For light shades he recommends the solution of alum to be decanted from the sediment that may have been deposited, and prefers dyeing them cold, using a bath more rich of colour. The silk is to be taken out as soon as it has acquired the proper tint, and the bath may be exhausted for other shades. He assures us, that with these precautions, fine colours of tolerable permanency may be obtained.

Mr. Poerner has made many experiments on methods that may be employed for dyeing cotton with brasil-wool by means of different mordants, as alum, solution of tin, sal ammoniac, pot-ash, &c. used either in the bath, or in the preparation of the cotton. He could not produce a colour however, that would stand washing with soap, though some would stand the action of the air, and washing with water, tolerably well. He recommends cotton thus dyed to be dried in the shade ^d.

To Mr. Brown, a gentleman of great zeal for the improvement of the arts, I am indebted for the following process, used by some manufacturers for giving cotton a crimson colour.

A solution of tin is prepared in the proportions of nitric acid two pounds, muriatic acid one pound, tin eight ounces, water one pound. The liquids being mixed together, the tin is to be added by little and little.

For a piece of cotton velvet weighing fifteen or sixteen pounds, a bath is prepared, consisting of boiling water four parts, strong decoction of galls two parts. Having stirred the bath with the rake, the piece is put in, worked for half

^d Versuche und Bemerkungen zum Nutzen der Farbekunst. Zweyter Theil.

an hour, and left to soak two hours, when it is taken out, and left to drain. Another bath being prepared with three buckets of boiling water, and one of decoction of brasil-wood, also boiling, is to be raked, and the piece worked in it an hour. This bath is to be thrown away, and the vat washed out, and then filled with a pure decoction of the wood, in which the piece is to be worked half an hour, and then raised on the winch. A bath of very clear river water, with a quart of solution of tin, being prepared and raked, the piece is to be worked in it a quarter of an hour. It is then raised on the winch, and set over the vat containing the bath of decoction of brasil-wood, one sixteenth of which is to be taken out, and replaced by an equal quantity of boiling decoction. This being raked, the piece is worked in it half an hour, raised on the winch, and carried back to the vat containing the solution of tin. These operations are performed alternately six or eight times, observing each time to take out a sixteenth of the bath of brasil-wood, and replace it with an equal quantity of boiling decoction of the same wood, to rake the bath of composition each time, and to finish the dyeing with the latter. The piece is to be

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be washed in the river, and dried in a dark place.

Methods have long been sought, for giving greater permanency to the fine and various colours obtained from brasil-wood at little expence. In using this substance we should call to mind some of its properties. The colouring matter of brasil-wood is easily affected and turned yellow by acids. It then becomes a permanent colour. But what distinguishes it from madder and kermes, and makes it resemble cochineal, is that it resumes its natural colour when precipitated in combination with alumine or oxyd of tin. These two combinations appear best calculated to render it durable. We should therefore seek the circumstances most proper to favour the formation of these combinations according to the nature of the stuff.

The astringent principle also appears to contribute to the permanency of the colour obtained from brasil-wood: but galling deepens it, and cannot be employed for light shades.

The colouring matter of brasil-wood is very easily affected by alkalis, which gives it a purple tint; and there are many processes in which alkalis, either fixed or volatile, are used
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to form violets and purples: but the colours obtained by these means, easy to be varied according to the intention, are perishable, and have only a temporary brightness. Alkalis do not appear to injure colours obtained from madder; but they accelerate the fading of most others.

It appears, from what Mr. Wilson says, that in England woods for dyeing are ground in mills constructed for that purpose, and kept moistened with urine; or if the latter be not done, a little alkali is added when they are boiled.

The custom of reducing the woods to powder is advantageous, and ought to be adopted: but putrid urine and alkali, whilst they favour the extraction of the colouring matter, and heighten its colour, may frequently counteract the effect to be obtained, and must be injurious to the permanency of the colour.

C H A P. XI.

Of Logwood.

INDIA, Jamaica*, or Campeachy wood, has received those different names from the places where it grows most plentifully. It is very common at Jamaica, and on the eastern shore of the bay of Campeachy; and is found also at St. Croix, Martinico, and Granada.

The tree is called by Linnæus *hæmatoxylum campechianum*. It grows very high and large in a good soil: the bark is thin, smooth, and of a bright gray, or sometimes yellowish: the trunk is straight and prickly: the leaves somewhat resemble those of the bay-tree in appearance, and also in their aromatic qualities, whence the tree has been called *aromatic bay*, or *Indian bay*: its seeds have been improperly called *clove-seeds*, from their flavour, and in England are known by the name of *Jamaica pepper*, or *all-spice*.

* In England, the name of Jamaica wood is commonly applied to the better species of mahogany, the inferior kind being brought from Honduras. T.

Logwood is so heavy as to sink in water, hard, compact, of a fine grain, capable of being polished, and scarcely susceptible of decay. Its predominant colour is red, tinged with orange, yellow, and black.

For use, its *juice* is commonly extracted like that of brasil-wood. It yields its colour both to spirituous and watery menstrua. Alcohol extracts it more readily and copiously than water. The colour of its dyes is a fine red, inclining a little to violet or purple, which is principally observable in its watery decoction. This, left to itself, becomes in time yellowish, and at length black. Acids turn it yellow: alkalis deepen its colour, and give it a purple or violet hue. Sulphuric, nitric, and muriatic acids, produce in it a small quantity of a precipitate, which is some time in separating, and its colour, with the sulphuric acid, is a dark red; with the nitric, feuilemort; with the muriatic, a lighter red. The supernatant liquor is transparent, of a deep red colour with the sulphuric and muriatic acids, and yellowish with the nitric. The oxalic acid forms a light marrone precipitate; the liquor remaining transparent, and of a yellowish red. The acetic acid acts nearly in the same manner, except that the colour of the precipitate is a little deeper. Tartar gives
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the same precipitate as vinegar, but the liquor remains turbid, and more inclined to yellow. Fixed alkali occasions no precipitate, but changes the decoction to a deep violet, which afterwards becomes nearly brown. Alum produces a pretty copious precipitate, of a lightish violet colour; the liquor remaining violet, and nearly transparent. Alum and tartar occasion a dark red precipitate in tolerable quantity; the liquor remaining transparent, and of a yellowish red. Sulphat of iron gives it instantly a blueish black colour, like that of ink; a pretty copious precipitate of the same colour forms, and the liquor remains turbid a long while; but if it be sufficiently diluted, and especially if there be a small excess of the sulphat, all the black matter is at length deposited. Sulphat of copper produces a very copious precipitate, of a browner and less bright black than the preceding: the liquor remains transparent, and of a very deep brownish or yellowish red. Acetite of lead instantly occasions a black precipitate with a slight reddish tinge; the liquor remaining transparent, and of the colour of very pale beer. Finally, tin dissolved in nitromuriatic acid forms immediately a precipitate of a very fine violet or purple, almost prune
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de monsieur: the supernatant liquor is very clear, and perfectly colourless.

Stuffs would take only a flight and fading colour from decoction of logwood, if they were not previously prepared with alum and tartar. A little alum is added also to the bath. By these means they acquire a pretty good violet.

A blue colour may be obtained from logwood, by mixing verdegris with the bath, and dipping the cloth till it has acquired the proper shade.

These uses of logwood have obtained it the names of violet wood and blue wood. Of these I shall speak more largely, when I come to treat of compound colours.

The grand consumption of logwood is for blacks, to which it gives a lustre and velvety cast (*velouté*), and for grays of certain shades. It is also of very extensive use for different compound colours, which it would be difficult to obtain of equal beauty and variety, by means of drugs affording a more permanent dye.

Juice of logwood is frequently mixed with that of brasil, to render colours deeper; their proportion being varied according to the shade desired.

Logwood is used for dyeing silk violet. For this the silk must be scoured, alumed, and

washed; because without aluming it would take only a reddish tinge, that would not stand wetting. To dye silk thus, it must be turned in a cold decoction of logwood, till it has acquired the proper colour: if the decoction were used hot, the colour would be in stripes and uneven.

Bergman has already observed, that a fine violet might be produced from logwood, by impregnating the silk with solution of tin, as has been said in the preceding chapter. In fact, we may thus obtain, particularly by mixing logwood and brasil in various proportions, a great number of fine shades, more or less inclined to red, from lilac to violet.

If decoction of logwood be substituted for that of brasil in the process communicated by Mr. Brown, a fine violet colour will be obtained; and if the two be mixed, we shall have shades of puce colour, and prune de monsieur, more or less inclining to red.

The remarks made on brasil are also applicable to logwood, the colouring matter of which exhibits similar properties.

SECTION

SECTION IV.

Of Yellow.

CHAP. I.

Of Weld.

WEELD or woald (*reseda luteola*, Lin.) is a plant very common in the environs of Paris, in most of the French provinces, and in a great part of the rest of Europe. It pushes out long narrow leaves, of a lively green: from the midst of these leaves the stalk rises to the height of three or four feet, frequently branchy, and furnished with leaves; narrow like the radical ones, but shorter as they approach the flowers, which are disposed in long spikes. The whole of the plant is used for dyeing yellow.

Two sorts of weld are distinguished. The bastard or wild, which grows naturally in the fields; and the cultivated, the stalks of which are smaller, and not so high. For dyeing, the

latter is preferred; it abounding more in colouring matter. The more slender the stalk, the more it is valued.

When the weld is ripe, it is pulled, dried, and made into bundles, in which state it is used.

When the decoction of weld is very strong, it has a yellow colour inclining to brown: if it be greatly diluted with water, its yellow, which is more or less pale, inclines a little to green.

If a little alkali be added to this decoction, its colour grows deeper, and after a certain time a little ash-coloured precipitate falls down, which is not soluble in alkalis.

Acids in general render its colour paler, and occasion a little precipitate, which will dissolve in alkalis, giving them a yellow colour inclining to brown.

Alum forms with it a yellowish precipitate, and the liquor retains a fine lemon colour. If a solution of alkali be poured into this liquor, a whitish yellow precipitate, soluble in alkalis, is thrown down, but the liquor still remains coloured.

Solution of common salt, or of muriat of ammoniac, renders the liquor turbid, and its colour at first a little deeper; by degrees a deep yellow precipitate forms, and the supernatant

natant liquor retains a pale yellow colour a little inclining to green.

Solution of tin produces a copious bright yellow precipitate: the liquor remains a long time turbid, but slightly coloured.

Sulphat of iron produces a plentiful dark gray precipitate, and the supernatant liquor is brownish.

Sulphat of copper occasions a brownish green precipitate, and the liquor preserves a pale green colour.

The yellow communicated to wool by weld has little permanency, if the wool be not previously prepared by some mordant. For this purpose alum and tartar are used, by means of which that plant gives a very pure yellow, which has the advantage of being permanent.

For the boiling, which is conducted in the common way, Hellot directs four ounces of alum to every pound of wool, and only one ounce of tartar: many dyers however, use half as much tartar as alum. Tartar renders the colour paler, but more lively.

For the welding, that is, for the dyeing with weld, the plant is boiled in a fresh bath, enclosing it in a bag of thin linen, and keeping it from rising to the top by means of a heavy

wooden croses. Some dyers boil it till it sinks to the bottom of the copper, and then let a cros down upon it : others, when it is boiled, take it out with a rake and throw it away.

Hellot directs five or six pounds of weld for every pound of cloth : but dyers seldom use so much, contenting themselves with three or four pounds, or even much less. Many indeed, add to the weld a little quicklime and ashes, which favour the extraction of the colouring matter, and heighten its colour, but at the same time render it liable to be changed by the action of acids. The quantity of weld however, ought to be proportionate to the depth of the shade to be obtained.

Lighter and brighter shades may be obtained by dyeing after deeper ones, adding water at each dipping, and keeping the bath boiling : but light shades procured in this way are not so lively as when fresh baths are used, proportioning the quantity of weld to the depth of the shade.

Common salt added to the weld bath renders its colour richer and deeper : sulphat of lime, or gypsum, also deepens it : but alum renders it paler and more lively ; and tartar, still paler. Sulphat of iron or vitriol makes it incline to brown. The shades obtained
from

from weld may be modified by such additions, by the proportion of the weld, by the length of the operation, and by the mordants employed in preparing the stuff. Thus Scheffer says, that by boiling the wool two hours with a fourth its weight of solution of tin, and the same of tartar, washing it and boiling it fifteen minutes with an equal weight of weld, it will take a fine yellow, which however, will not penetrate its internal texture. Mr. Poerner also directs the cloth to be prepared as for dyeing scarlet. By these means greater brightness and permanency are given to the colour, which (*cæteris paribus*) is at the same time lighter.

The colour may be modified also by passing the cloth, when it comes out of the dye, through another bath. Thus, to produce a golden yellow, the cloth, when it comes out of the welding, may be passed through a slight madder bath; and for a tawny, (*tannée*) through a bath made with a little foot. These methods will be mentioned in treating of faddening.

To dye silk plain yellow, in general no other ingredient than weld is used. The silk ought to be scoured in the proportion of twenty pounds of soap to the hundred, and afterwards

alumed and refreshed, that is, washed after the aluming.

A bath is prepared with two pounds of weld for each pound of filk, which after a quarter of an hour's boiling, is to be passed through a sieve or cloth into a vat ; when it is of such a temperature as the hand can bear, the filk is put in, and turned until the colour is become uniform : during this operation the weld is boiled a second time in fresh water ; about half of the first bath is taken out, and its place supplied by a fresh decoction. This fresh bath may be used a little hotter than the former ; too great a degree of heat however must be avoided, that no part of the colour already fixed may be dissolved ; it is to be turned as before, and in the mean time a quantity of cendres gravelées is to be dissolved in a part of the second decoction ; the filk is to be taken out of the bath, that more or less of this solution may be put in, according to the shade required. After it has been turned a few times, a hank is wrung with the pin, that it may be seen whether the colour be sufficiently full, and have the proper gold cast : if it should not, a little more of the alkaline solution is added, the effect of which is to give the colour a gold cast, and to render it

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it deeper. In this way the process is to be continued, until the silk has attained the desired shade; the alkaline solution may also be added along with the second decoction of the weld, always taking care that the bath be not too hot.

If we wish to produce yellows with more of a gold or jonquille colour, a quantity of annotta proportioned to the shade required, must be added to the bath along with the alkali.

For the light shades of yellow, such as pale lemon, or canary-bird colour, the silk ought to be scoured as for blue, because the shades are more beautiful and transparent, in proportion as the ground on which they are laid is whiter: the strength of the bath is proportioned to the shade we wish to obtain; and if we intend that the yellow should have a tinge inclining to green, more or less of the indigo vat is added, if the silk has not been azured. To prevent the shades from being too deep, the silk may be more slightly alumed than usual.

Scheffer directs that the silk should be soaked twenty-four hours in a solution of tin, made with four parts of nitric acid, one of common salt, and one of tin, and saturated with tartar; that it should be washed, and boiled half an hour

hour with an equal quantity of weld flowers. He says, that a fine straw colour is thus obtained, which possesses the advantage of resisting the action of acids. By following this process, very little tin should be left in the solution, because the acid of tartar precipitates it.

In dyeing cotton yellow, we begin by scouring it in a bath prepared with the ley of the ashes of green wood ; it is then washed, dried, and alumed with one fourth of its weight of alum ; after twenty-four hours it is taken out of the aluming, and dried without being washed. A weld bath is then prepared, with the proportion of a pound and a quarter of weld for each pound of cotton, in this the cotton is dyed, by being turned and wrought in it until it has acquired a proper shade ; it is taken out of this bath to be soaked for an hour and a half, in a solution of sulphat of copper or blue vitriol, in the proportion of one fourth of the weight of the cotton ; it is then thrown, without being washed, into a boiling solution of white soap made with the same proportions ; after being well stirred, it is boiled in it for nearly an hour, then well washed and dried.

If a deeper yellow be required, the cotton is not alumed, but two pounds and a half of weld for each pound of cotton are employed, to which a dram of **verdegris** mixed with a part of the bath is added ; in this, the cotton is dipped and worked, until it has acquired an uniform colour ; it is then taken out of the bath, that a little ley of soda may be poured in ; returned into the bath and kept there for a full quarter of an hour, when it is taken out, wrung, and dried.

Lemon colour is dyed by the same process, except that only one pound of weld is employed for each pound of cotton, and that the proportion of **verdegris** may also be diminished, or even entirely omitted, aluming being substituted in its stead. The shades of yellow may thus be varied in many different ways. The processes for thread are the same.

For the yellow colours on printed cotton, the stuff is impregnated by means of engraved stamps, with the mordant described when treating of madder, made by the mixture of acetite of lead or salt of saturn and alum ; the yellow colour, which the parts not impregnated with the acetite of alumine have acquired, is then discharged, by the action of bran and exposure on the grass. The same mordant

might undoubtedly be employed with success for cotton and linen to be dyed yellow.

C H A P. II.

Of Yellow-Wood, Fustic, Bois jaune.*

THIS wood is obtained from a large tree (*Morus Tinctoria*) which grows in the Antilles, and principally at Tobago. It is of a yellow colour, as its name expresses, with orange veins. Its medullary productions are very small, it is not very hard or heavy.

This wood has been extensively used in dyeing only within these few years; it abounds much in colouring particles, and affords a very permanent colour, it unites well with indigo, and bears a moderate price; in short, it possesses qualities which entitle it to a place among the most useful ingredients in dyeing.

* I have translated *bois jaune*, fustic, because the *Mor. Tinct.* is universally so called by our botanists, though V. de Bomare makes it the *tulipifera*. Vid. Hort. Kewens. T.

A strong decoction of this wood is of a deep reddish yellow colour ; when diluted with water, it becomes of an orange yellow. Acids with some slight differences, render this liquor turbid, a small quantity of a greenish yellow precipitate is formed, the supernatant liquor is of a pale yellow : alkalis redissolve the precipitate, and give the liquor a deep reddish colour.

This is the colour which alkalis produce in a decoction of fustic, they deepen it much and make it almost red. After some time, a yellowish substance is separated, which adheres to the vessel, and sometimes swims at the top.

Alum forms a small quantity of a yellow precipitate, the liquor remains transparent but of a lighter yellow.

Alum and tartar produce a precipitate of the same colour, but which is more slowly formed, the colour of the liquor is still paler.

Muriat of soda or common salt, makes the liquor somewhat deeper coloured, but without rendering it turbid.

Sulphat of iron forms a precipitate which is at first yellow, but afterwards becomes more and more brown, the liquor remains brown and turbid.

Sulphat

Sulphat of copper gives a great quantity of a brownish yellow precipitate ; the supernatant liquo: remains of a very slightly greenish colour.

Sulphat of zinc gives a greenish brown precipitate, the liquor remains of a reddish yellow.

For use, yellow wood must be split, or what is better, cut into chips, and enclosed in a bag, that no part of it may fix in the stuff and tear it.

Weld gives a cloth which has not been prepared, only a pale yellow, which soon changes in the air ; but fustic without the aid of mordants gives it a brownish yellow, which is dull indeed, but which stands very well when exposed to the air ; its colour is rendered more bright and fixed, by the mordants employed with weld, which act on it in a similar manner ; thus alum, tartar, and a solution of tin, render the colour brighter ; common salt, and sulphat of lime or gypsum, render it deeper. We may then treat fustic in the same way as weld, with only this difference, that in order to obtain the same shade, much less yellow wood is required ; thus from five to six ounces of this wood are sufficient to give a lemon colour to a pound of cloth, but the colours obtained
from

from it incline more to orange, than those obtained from the weld ; and therefore, they are sometimes used together in quantities proportioned to the effect we wish to produce.

C H A P. III.

Of Annotta.

ANNOTTA, rocou, or roucou, is a somewhat dry, hard paste, brownish on the outside, and of a fine red within ; it is usually brought to us in cakes of two or three pounds weight, wrapped up in very large reed leaves, from America, where it is prepared from the seeds of a certain tree (*Bixa Orellana*, Lin).

Father Labat says, that the Americans possess a species of annotta, which has a more beautiful and durable colour than that brought to us ; and that in order to prepare it, they bruise the seeds with their hands moistened with oil, and detach with a knife, the paste
that

that is formed, and then dry it in the sun; whereas they prepare the annotta for sale, by pounding the seeds with water, in which they are left to ferment. Annotta dissolves much better and more easily in alcohol, than in water, hence it is employed in yellow varnishes that are designed to have an orange cast.

The watery decoction of annotta has a strong smell, and a disagreeable taste, its colour is of a yellowish red, it is somewhat turbid; an alkaline solution changes it to an orange yellow, which is brighter and more pleasing; a small quantity of a whitish substance is separated from it, which remains suspended in the liquor. If we boil annotto in water with an alkali, it dissolves much better than in water alone, and the liquor is of an orange colour.

Acids form with this liquor an orange-coloured precipitate soluble in alkalis, which communicate to it a deep orange colour; the supernatant liquor retains only a pale yellow.

Solutions of common salt and sal ammoniac produce no sensible change.

The solution of alum gives a considerable quantity of orange precipitate, which is deeper than that which acids produce, the liquor remains of a pleasant lemon colour, bordering a little on a green.

Sulphat

Sulphat of iron forms a precipitate of an orange brown; the liquor remains of a pale yellow.

Sulphat of copper gives a precipitate of a yellowish brown somewhat brighter than the former; the liquor preserves a greenish yellow colour.

A solution of tin produces a lemon-coloured precipitate, which is deposited very slowly.

When annotta is used, it is always mixed with an alkali, which facilitates its solution, and gives a colour less inclining to red. It is cut in pieces, and boiled in a caldron, with an equal weight of cendre gravelée, provided the desired shades do not require a smaller proportion of alkali; the cloth may be then dyed in this bath, either with these ingredients alone; or with the addition of others to modify the colour; but it seldom happens that annotta is used for wool, because the colours it imparts are too fading, and may be obtained of a more durable nature by other means. Hellot employed it in dyeing a stuff prepared with alum and tartar, but the permanency of the colour was not much increased, it is almost solely used for silk.

For silks to be dyed of an aurora, or orange colour, it is sufficient to scour them with twenty

pounds of soap to the hundred ; after they have been well cleansed, they may be immersed in a bath of water, with which more or less of the alkaline solution of annotta (according to the shade required) has been carefully mixed. The heat of this bath ought to be between tepid and boiling water.

When the silk has acquired an uniform colour, one of the hanks must be taken out, washed and wrung, to see whether the colour be sufficiently full, and if it be not, more solution of annotta must be added, and it must be turned again. This solution preserves its colour unchanged.

When the desired shade has been obtained, nothing remains but to wash the silks, and to beetle them twice, by a stream of water, to free them from the superfluous annotta, which would injure the beauty of the colour.

When raw silk is to be dyed, such as is naturally white must be chosen, and it must be dyed in the annotta bath, which ought only to be tepid, or even cold, that the alkali may not dissolve the gum of the silk, and destroy its elasticity, which we wish to preserve.

What has been now said respects the silk intended to receive the aurora colour : to make the orange, which contains more red, after dyeing

dyeing with annotta, it is necessary to redden the silks with vinegar, alum, or lemon juice. The acid, in saturating the alkali used to dissolve the annotta, destroys the yellow shade which the alkali had imparted, and restores its natural colour, which inclines a good deal towards red.

For the very deep shades, it is the practice at Paris, as Mr. Macquer informs us, to alum them; and if the colour is not yet red enough, to pass them through a weak bath of brasil-wood. At Lyons, the dyers, who use carthamus, sometimes employ the old baths made with that ingredient for the deep orange colours.

When orange colours have been reddened with alum, they must be washed in a stream of water, but it is not necessary to beetle them, unless the colour be too red.

Shades which preserve a reddish hue may likewise be obtained by a single operation, namely, by employing in the preparation of the annotta bath, a smaller quantity of alkali than that above directed.

• Mr. Gihliche advises us not to employ heat in the preparation of annotta. He directs that it should be put into a glass vessel, or one of earthen ware with a vitreous coat, and that as much

solution of pure alkali should be added as will cover it, and that this mixture should be left at rest for twenty-four hours; that the liquor should then be decanted, and filtered, and the residuum repeatedly washed with water, leaving the mixture at rest each time for two or three days, till the water no longer receives any colour; that these liquors should be all mixed together, and put into a well stopped vessel and kept for use.

He directs that the silk should be steeped for twelve hours in a solution of alum, in the proportion of two ounces of the salt to a pound of the silk, or in water acidulated with the acetic acid before described; when taken out of this mordant, it is to be well wrung.

The silk thus prepared is put into the annotta bath quite cold, and kept there, and stirred about, until it has acquired the proper shade, or it is kept at a degree of heat far below ebullition; when taken out of the bath, it is washed and dried in the shade.

For the brighter shades, a liquor is employed, which is less loaded with colour, to which may be added a little of the acid liquor, which has been used as a mordant, or the dyed silk may be passed through acidulated water.

If we wish to have the last shades with less of an orange cast, and approaching to nankeen, a small quantity of solution of galls in white wine may be added to the bath.

To give an orange colour to cotton, Mr. Wilson directs the annotta to be ground while it is kept moistened, boiled in water with double its weight of alkali, left to settle for half an hour, and the clear liquor to be put into a heated vessel; in this, the cotton is to be immersed, when it will take an orange colour. A hot solution of tartar is then to be poured into the bath, so that it may become weakly acidulated, it is to be again turned in it on the skein sticks, or wound upon the winch when in the piece; in this way, the colour becomes more lively, and fixes better; they then wash the cotton slightly and dry it in a stove.

C H A P. IV.

*Of Saw-wort and several other Substances
which dye Yellow.*

SAW-WORT (*farette*) *ferratula tinctoria*, is a plant which grows abundantly in meadows and woods. Without mordants, it gives a yellowish green colour which has no durability; but by means of alum, employed either in a separate boiling, or put into the bath with the saw-wort, it gives a yellow colour which is both pleasing and durable. According to Mr. Poerner, the best mordants for it, are alum, and sulphat of lime. It is unnecessary to repeat, that the latter produces the deepest colour, the shade of which may also be varied by the proportions of mordant and saw-wort. Scheffer directs that the wool should be prepared with alum and one-twelfth of tartar: he says, that if it be prepared with three-sixteenths of solution of tin and as much tartar, it acquires a much brighter colour than in the former case.

Dyers broom, or dyers weed, (*la genestrole*) *genista tinctoria*, which grows plentifully in dry
and

and mountainous foils, gives a yellow colour, not comparable in beauty to that of weld, or saw-wort, but which becomes sufficiently fixed by means of mordants, the most advantageous of which, either for the preparation of the cloth, or for being put into the bath, are tartar, alum, and sulphat of lime.

Camomile (*anthemis tinctoria*) *camomilla matricaria*, a well known plant, gives a weak yellow colour of a tolerably pleasant hue, but without durability; mordants give it a little; the most useful of these are alum, tartar, and sulphat of lime.

According to Scheffer, a very fine yellow may be given to silk with a decoction of this plant, into which a little solution of tin mixed with tartar till its colour is become yellow, has been added drop by drop; for dyeing the silk, it is kept warm, but without boiling: he recommends that good water which does not precipitate solution of tin should be employed.

Fenugreek (*trigonella fænugræcum*) affords seeds, which when ground, are capable of giving a pale and tolerably durable yellow: the mordants which succeed best with this substance, are alum, and common salt.

Turmeric (*terra merita*) *curcuma longa*, is a root brought to us from the East-Indies. I have

had an opportunity of examining some turmeric which came from Tobago, which was superior to that which is met with in commerce, both in the size of the roots, and the abundance of colouring particles. This substance is very rich in colour, and there is no other which gives a yellow colour of such brightness, but it possesses no durability, nor can mordants give it a sufficient degree: common salt and ammoniacal muriat are those which fix the colour best, but they render it deeper, and make it incline to brown, some recommend a small quantity of muriatic acid. The root must be reduced to powder to be fit for use. It is sometimes employed to give the yellows made with weld a gold cast, and to give an orange tinge to scarlet; but the shade the turmeric imparts soon disappears in the air.

Mr. Gihliche gives two processes for fixing the colour of turmeric on silk. The first consists in aluming in the cold for twelve hours, a pound of silk in a solution of two ounces of alum, and dyeing it hot, but without boiling, in a bath composed of two ounces of turmeric, and a quart (measure) of aceto-citric acid mixed with three quarts of water. The second process consists in extracting the colouring particles from the turmeric by aceto-citric acid,

acid, in the way described for brasil-wood, and in dyeing the silk alumed as already mentioned in this liquor, either cold, or only moderately warm. The colour is rendered more durable by this, than by the former process. The first parcel immersed acquires a gold yellow; the colour of the second and third parcels are lighter, but of the same kind; that of the fourth is a straw colour. Mr. Gühliche employs the same process to extract fine and durable colours from fustic, broom, and french berries: he prepares the wool by a slight aluming, to which he adds a little muriatic acid; he seems to content himself in these cases with vinegar or some other vegetable acid, instead of his aceto-citric acid for the extraction of the colour; he directs that a very small quantity of solution of tin should be put into the dye-bath.

Venus's sumach (fustet) *rbus cotinus**, is a wood the colour of which is orange and greenish, with fibres of a shining appearance; it is made use of in the form of chips.

* According to the best intelligence I can obtain from our dyers, they never employ this substance; the *morus tinctoria*, or bois jaune, being among them distinguished by the name of fustic. T.

This wood gives a fine orange colour possessed of no durability ; so that it is not employed alone but mixed with other colouring substances, particularly cochineal, to give a fire colour to scarlet, for pomegranates, jujubes, langoustes, oranges, jonquilles, gold colours, buffs, and in general for all those colours which it is wished should have somewhat of an orange hue. The advantage derived from the use of this substance is, that its colour is weakened and discharged, without the hue being changed ; besides, when it is united with other colours it is more durable than when alone.

French berries (la graine d'Avignon) *rhamnus infectorius*, gives a pretty good yellow but void of durability ; when employed, the cloth is prepared in the same manner as for dyeing with weld.

The leaves of the willow are mentioned by Scheffer as proper for giving a fine yellow colour to wool, silk, and thread. Bergman asserts that the leaves of the sweet willow (laurier faule) *salix pentandra*, should be employed, and that the leaves of the common willow give a colour, which is for the most part discharged by the sun in a few weeks.

Scheffer directs that the wool should be left a whole night in a cold solution of three ounces
of

of alum, and one ounce of tartar to the pound. The boiling is made with leaves gathered about the end of August or beginning of September, dried in a shady but airy place: as much of these as is thought proper is boiled for half an hour, and half a dram of white pot-ash for each pound is added, to render the colour more bright and deep, and the bath is passed through the sieve; it is kept nearly boiling, and the wool left in it, until it has taken the desired colour. He directs the same process for silk, and for thread, except that the proportion of alum is increased an ounce per pound. According to Bergman's account, Mr. Alstroemer has observed that the colour was rendered richer by soaking the thread with six ounces of alum, wringing and drying it, before being dyed; and that half an ounce of pot-ash per pound was required, for the complete extraction of the colouring matter.

According to M. d'Ambourney, the bark and more especially the young branches of the Italian, and some other species of poplar, give wool a beautiful and permanent yellow, particularly when it has been prepared with solution of tin; nearly seven parts by weight of this wood, are required to dye one of wool.

The seeds of purple trefoil (*trifolium pratense purpurcum majus*, Raii.) are employed in dyeing, in England and Switzerland. Mr. Vogler has endeavoured to discover what colours might be obtained from them; and has found that a bath of this seed and solution of pot-ash, afforded a very deep yellow; with sulphuric acid, a light yellow; with solutions of alum and tin, a lemon colour; with sulphat of copper, a greenish yellow. Wools impregnated with these mordants, and boiled for some minutes in a bath of red trefoil seed, are found to be permanently dyed of the colours above mentioned; these yellows give a fine green with indigo: lucern (*medicago sativa*) afforded Mr. Vogler the same results ^b.

M. Dizé has made experiments of comparison on trefoil and weld ^c: whence it appears that the trefoil seed gives wool a fine orange yellow, and silk a greenish yellow; that solution of tin cannot be employed in this dye, but that aluming is necessary; lastly, that the blue applied upon the yellow produced by the trefoil, gives a less beautiful, and more

^b Ann. de Chym. tom. iii. ^c Journ. de Phys. 1789.

dull green, than that for which weld has been employed.

Common Canada golden rod (*solidago canadensis*) had already been recommended by Hellot. M. Gaad had remarked in the Stockholm memoirs, that this plant afforded a yellow colour even superior to that of weld, and greatly preferable to that of dyers-weed ; as however, its use has not been adopted, though the plant is easily cultivated, M. Succow has subjected it to fresh trials. I shall pass over the experiments with reactives, which afford nothing particular. A decoction of the stalks of this plant, to which the author had added a considerable proportion of alum, gave a pattern of cloth which had received no preparation, a very lively straw colour ; to another pattern prepared with sulphat of iron, a greenish yellow ; and a very pure and lively lemon colour to a third pattern, which had been prepared with alum.

The flowers of french marygold (*tagetes patula*) separated from their calices, were subjected to the same trials. The cloth without preparation acquired a deep yellow colour in a decoction of these flowers ; when prepared with sulphat of iron, a greenish colour, which by a continuance of boiling became very deep ; finally, cloth

cloth prepared with alum, acquired a very bright yellow inclining a little to green. If a little alum be added to the bath before the stuff is put in, a very fine and lively yellow is obtained, which has even more brightness than that produced by the Canada golden rod.

Dr. Bancroft has made known the use of the bark of a kind of oak, called yellow oak, in New-England, and has obtained an exclusive right to the traffick of this bark in France and England : he calls it quercitron ^d.

According to Dr. Bancroft, the quercitron bark may be advantageously substituted for weld in the printing of linens, but it must be only simply infused in warm water, and only one part employed, instead of ten of weld.

To dye wool yellow, Dr. Bancroft advises that solution of tin and alum should be put into the bath with the quercitron. Silk ought to be treated in the same manner as with weld : if a very bright yellow is required, it must be prepared with solution of tin.

It appears from some information for which I am indebted to Mr. Brown, that many manufacturers of printed linens in England, at present prefer this bark to weld, because it

^d Instructions, &c.

is considerably cheaper and the ground whitens more easily. Some find it advantageous to mix a certain proportion of decoction of weld with the quercitron bath, which should be exposed to only a gentle heat. M. d'Ambourney asserts, that to obtain the advantages set forth by Dr. Bancroft, the wool must be first prepared with solution of tin, and then his process followed.

There is a great number of other substances which are employed to dye yellow, and which afford shades endued with different degrees of beauty and durability ; of this sort is the bark of the berberry (*l'épine-vinette*), wild chervil, or cow-weed (*cerfeuil sauvage*), common stinging-nettle (*grande ortie*), the root of patience dock (*patience sauvage*), bark of the ash (*frêne*), the leaves of the almond, peach, and pear-tree, flowers of common furze (*jonc marin*), &c. We have also seen in the first part of this work that the nitric acid might be employed to produce a yellow colour.

According to the observations of Lewis, white flowers give even a deep yellow colour to the water in which they are boiled ; acids, alkalis, and other salts have the same effect upon this colour, as upon those of other
yellow

yellow vegetable substances *. Mr. Gühliche gives a process for dyeing silk of a straw colour, with the white flowers of the acacia, such as is difficultly obtained in equal perfection by other substances. Having collected these flowers and dried them in the shade, he submitted them to a slight roasting, keeping them stirred in a vessel heated by means of live coals ; when they have become yellow, he adds to them such a quantity of lime water as takes a pretty deep colour ; he digests this mixture in a gentle heat, until the flowers are become white, and then filters the liquor. For a pound of silk, he adds to a bath made with four ounces of dry flowers, half an ounce of powdered oyster shells, two drams of alum, or a little aceto-citric acid. In this bath while still warm, he dyes the silk, which has either received a very slight aluming, or has been steeped in the acid liquor ; a little solution of indigo produces a beautiful shade of light green with this yellow.

It appears that the substances which may be employed to dye yellow are very numerous ; they differ from each other in the quantity of their colouring matter, in their dye being

* The chemical works of Caspar Neumann.

more or less free, more or less inclining to orange or green, in possessing different degrees of brightness and durability, and in their price. These properties taken together, ought to regulate our choice, according to the quantity of the stuff, the colour required, and the particular circumstances in which we are placed.

In general, alkalis render the colour of these substances deeper and more of an orange cast; they facilitate the extraction of the colouring particles; it is indeed only by means of them that we obtain the particles from annotta, but they also favour their destruction. Sulphat of lime or gypsum, common salt, and sal ammoniac render the colour of yellow substances deeper; acids render it more clear and more durable; alum and solution of tin, while they render it more clear, also confer greater brightness and durability. Silk may be advantageously prepared with solution of tin; as we have seen that it ought to be, in order to take a durable colour from brasil and logwood.

SECTION V.

Of Fawn Colour (*fauve*).

I SHALL give an analysis of only some of the substances employed to produce fawn colours ; because the number of those which may be employed, is too great to admit of a particular examination of each, and they bear so near a resemblance to each other, that the observations made on some will apply to the remainder.

CHAPTER I.

Of Walnut-Peels.

WALNUT-PEELS form the green covering of the nut : these, it is well known, are white internally, but grow brown or black when exposed to the air, whence it happens,

happens, than when the skin has been impregnated with their juice, it soon assumes a brown or almost black colour.

If the internal part of the fresh peel be immersed in very weak oxygenated muriatic acid, it also acquires a brown colour in that fluid.

The filtered decoction assumes a deep brown colour in the air; on evaporation, it affords pellicles which, when removed, well washed, and dried, are nearly black; the liquor separated from the pellicles affords a brown extract, which may be redissolved completely in water, but which by a fresh evaporation, again yields pellicles similar to the former.

These pellicles which are formed in many other evaporations, are owing to the colouring matter, the properties of which have been changed by a slight combustion.

Alcohol precipitates the colouring particles from the decoction of walnut-peels, in the form of a brown substance, which may be redissolved in water.

Solution of pot-ash produces no sensible change at first, in the decoction of walnut-peels; by degrees it grows a little turbid, and the colour becomes deeper.

The muriatic acid rendered the colour more clear, and reduced it to a yellow; a little brown precipitate was formed, and the liquor remained of a clear yellow.

Solution of tin produced in the decoction a copious fawn coloured precipitate, inclining to an ash colour; the liquor retained only a flight yellow colour.

Solution of alum rendered the liquor slightly turbid; a very little brownish fawn coloured precipitate was formed, the liquor had a lighter hue, but was still fawn coloured.

Solution of sulphat of copper rendered this liquor turbid very slowly; a small quantity of brownish green sediment was formed; the supernatant liquor remained green.

Acetite of lead quickly produced a copious precipitate of a deep fawn colour.

Solution of sulphat of iron rendered the colour much deeper and even black; by dilution with water it was changed to brown, and to a greenish fawn colour, but no sediment was formed.

Solution of common vitriol of zinc rendered the colour much deeper, but produced no precipitate.

Solution of pure sulphat of zinc only rendered the liquor slightly turbid ; by which its colour was a little darkened,

A decoction of walnut-tree root exhibits very nearly the same properties : when the bark was separated from the ligneous part of the root, an equal weight of the former afforded a liquor much more loaded with colour. The bark of the wood of the walnut-tree also exhibited properties resembling those of the walnut-peels, but its decoction formed a blackish precipitate with sulphat of iron.

I have found that walnut-peels had a brisk action on oxyd of iron ; they dissolve it and form a black liquor like ink ; if they be boiled with pure filings of iron, these are not acted upon, but when left exposed to the air, the liquor soon becomes black.

The colouring particles of walnut-peels have a strong disposition to combine with wool, and give it a very durable hazel or fawn colour ; mordants appear to add little to its durability, but are capable of varying its shades, and giving them greater brightness. By means of alum in particular, when the stuff is prepared with it, a richer and more lively colour is obtained.

The use of walnut-peels is very advantageous, for they give shades which are sufficiently pleasing, and very durable ; and as they are employed without a mordant, they preserve the softness of the wool, and require only a simple and very cheap process.

The peels are gathered when the nuts are perfectly ripe, and large casks are filled with them, and as much water added as will cover them. In this state they are kept a year or more at the Gobelins, where the use of them is very extensive and various ; they are preserved for two years before they are used : it is found that they then yield much more colour. They have a very disagreeable putrid odour.

The peel separated from the nuts before they are ripe may also be employed, but it does not keep so long.

When walnut-peels are to be employed for dyeing, a quantity, proportioned to that of the stuff and the depth of the shade required, is boiled for a full quarter of an hour in a copper. In cloths, the deepest shades are commonly dyed first, and the lighter ones afterwards ; but for woollen yarn, the light shades are generally dyed first, and the deeper ones afterwards, fresh peels being added for each

each parcel. Cloth and yarn should be simply moistened with warm water before they are put into the copper, where they are carefully stirred until they have acquired the proper shade, unless they have had a previous aluming.

The root of the walnut-tree gives the same shades, but for this purpose, the quantity must be increased; it must be reduced to chips, and should be put into a bag, that the small bits may not stick to the stuff. It readily happens that the colour turns out unequal and spotted: to avoid this inconvenience, the fire must be kept low at the beginning, that the colouring particles may be distributed through the bath, in proportion as they are extracted from the root. If any of the parts should be dyed unequally, as the colour is a fixed one, there is no other remedy, but to reserve the stuff for a deeper colour.

I have dyed different patterns of wool with decoction of walnut-peels, adding to one, oxyd or calx of tin, to another, oxyd or flowers of zinc, to a third, semivitrified oxyd of lead or litharge, to a fourth, oxyd of iron. The quantity of decoction, weight of the pattern, time of boiling, and all other circumstances were equal, both with respect to these, and

another pattern which was treated without addition, and intended to serve as a standard of comparison; the oxyd of tin gave a more clear and bright fawn colour, than that of the standard; the oxyd of zinc a colour still more clear, and approaching to an ash-coloured gray; the oxyd of lead, a colour with more of an orange cast; the oxyd of iron, a greenish brown colour.

C H A P. II.

Of Sumach, and some other Substances proper for giving a Fawn Colour.

COMMON sumach (*rbus coriaria*) is a shrub that grows naturally in Syria, Palestine, Spain, and Portugal, in the two last it is cultivated with great care; its shoots are cut down every year quite to the root, and after being dried, they are reduced to powder by a mill, and thus prepared for the purposes of

of dyeing and tanning. The sumach cultivated in the neighbourhood of Montpellier is called *rédioul* or *roudou*.

The infusion of sumach, which is of a greenish fawn colour, soon becomes brown by exposure to the air : a solution of pot-ash produces but little change on it while recent ; acids brighten its colour and turn it yellow ; solution of alum renders it turbid, and produces in it a small quantity of yellow precipitate ; the liquor remains yellow.

Acetite of lead produced immediately a considerable quantity of yellowish precipitate, the surface of which was brown ; the liquor remained of a clear yellow.

Sulphat of copper produced a copious precipitate of a yellowish green, which after some hours changed to a brownish green ; the liquor remained clear and slightly yellow.

Common sulphat of zinc rendered the liquor turbid, darkened its colour, and produced a deep blue precipitate.

Pure sulphat of zinc did not deepen the colour nearly so much, only a small quantity of a brownish fawn-coloured precipitate was produced.

Muriat of soda or sea salt, at first produced no sensible change ; but after some hours, the liquor

liquor became somewhat turbid, and its colour was rendered a little more clear.

Sumach acts on a solution of silver just as galls do, it reduces the silver to its metallic state, and the reduction is favoured by the action of light. I have elsewhere enlarged on the explanation of this phenomenon, and the inferences to be drawn from it.

Of all astringents, sumach bears the greatest resemblance to galls: the precipitate however, produced in solutions of iron, by an infusion of it, is less in quantity than what is obtained by an equal weight of galls, so that in most cases, it may be substituted for galls, the price of which is considerable, provided we proportionally increase its quantity.

Sumach alone gives a fawn colour inclining to green; but cotton stuffs which have been impregnated with printers mordant, that is acetate of alumine, take a pretty good and very durable yellow. An inconvenience is experienced in employing sumach in this way, which arises from the fixed nature of its colour; the ground of the stuff does not lose its colour by exposure on the grass; so that it becomes necessary to impregnate all the stuff with different mordants to vary the colours, without leaving any part of it white.

The

The bark of the birch tree*, (*betula alba*) affords a decoction of a clear fawn colour, which soon becomes turbid, and changes to a brown; by exposure to the air with a solution of alum, a yellow precipitate in considerable quantity is formed; with a solution of tin, a copious precipitate of a clear yellow colour is produced; it blackens the solutions of iron, producing a considerable quantity of precipitate, so that it contains a good deal of the astringent principle: it dissolves a pretty large quantity of oxyd or calx of iron; hence arises the custom of employing it in the black vats intended for dyeing thread; it does not however possess the property of dissolving iron, in the same degree as the decoction of walnut-peels does.

The number of substances which are capable of producing fawn colours, might be greatly extended; almost all vegetables containing, (particularly in their bark) a greater or less quantity of colouring particles, fitted for giving different shades of fawn colour, inclining to yellow, brown, red, or green. These colouring particles vary in quantity, and even in quality, according to the age, the kind of

* According to the author, *ecorce de l'aune*. T.

vegetable, and the climate in which it grows. Great variety of shades may be produced, by modifying the natural fawn colour of vegetables, by means of different mordants. This has been carried into execution by Mr. Siefert^b, and particularly by Mr. d'Ambourney^c. In the great number of experiments which Mr. d'Ambourney has made with different vegetables, modified by different mordants, we observe, that the colours which he produced are for the most part between a yellow and brown, such as carmelites, olives, cinnamons, and marrons.

The decoction of most vegetables, and particularly of their bark, not only affords the same colour, differing only as to shade, but also shews nearly the same properties with re-actives; with alum, it forms a more or less deep yellow precipitate, and with solution of tin, a clearer yellow: on solutions of iron, it acts as an astringent; decoction of walnut-peels however affords a singular exception with respect to solution of iron: it assumes a very

^b Versuche mit einheimischen farbe materien.

^c Recueil de procédés & expériences sur les teintures solides que nos végétaux indigenes communiquent aux laines, & aux lainages.

deep colour, but no precipitation takes place, even after three or four days.

It would appear that this property of walnut-peels, which is also observable in the root of the walnut-tree, depends on the tendency which its compound with the oxyd of iron has, to remain united with the acid; for the decoction has a powerful action on the oxyd of iron, it becomes saturated with it, and forms a black liquor, and if even filings of iron be put into this decoction, left exposed to the air, a black liquor is formed in two or three days, by means of the oxygen it attracts from the atmosphere. If the decoction with the addition of sulphat of iron be boiled, a considerable quantity of black precipitate is instantly formed. It is only then in a very trifling circumstance, that walnut-peels and the bark of the walnut-tree differ from the other substances which afford a fawn colour; but their extractive part possesses in a remarkable degree, the property of growing black by the action of the air, and the pellicles which it has formed when it is evaporated, acquire in a very marked degree the appearance of a coaly substance.

I have endeavoured to give the rationale of those general properties of the substances which produce a fawn colour, and which must, in a greater

greater or less degree, be looked upon as astringents^d: I have considered them to be the produce of the colouring substance formed in the leaves and flowers, and which entering into the circulation which is proper to vegetables, have undergone, both by the action of the external air, and of that contained in the air vessels of vegetables, a species of combustion, by which their hydrogen is diminished and their carbonaceous principle becomes predominant.

If the yellow colour which many vegetable substances produce, be compared with the fawn colour which most of them yield, a near connection will be found between these colours; there are even some which may be referred equally to yellow or to fawn colour: there are some which are fawn coloured, but which by means of alum and solution of tin become yellow, and these yellows are very durable. This difference may be established between them: the yellows are in general less fixed, and more liable to give fading colours; because they have not been reduced to a permanent state, by a combustion so far advanced as that which the fawn colours have undergone; and therefore the colour of yellow substances requires to

^d Ann. de Chym. tom, vi.

be fixed by means of mordants, whereas, most fawn-coloured substances yield of themselves a colour which is sufficiently durable.

As the fawn-coloured shades obtained from different substances vary even to a great extent, several of these substances are sometimes mixed together in different proportions, to produce a particular colour; they are also mixed with other substances, to modify the colour obtained from them, and to make it more fixed.

Among these substances there is still one which merits attention, that is *saunders* or *sandal*.

Three sorts of saunders are distinguished, the white, the yellow, and the red; the last is the only one employed in dyeing: it is a solid, compact, heavy wood, brought to us from the coast of Coromandel, which grows brown by remaining exposed to the air: it is commonly employed ground into very fine powder; it gives a fawn colour with a brownish cast inclining to red; of itself it gives little colour, and it is said to make the wool harsh; but its colouring matter dissolves better when it is mixed with other substances, such as walnut-peels, sumach, and galls; besides, the colour which it gives is durable, and advantageously modifies those of other substances with which it is mixed.

Mr. Vogler

Mr. Vogler having observed, that diluted alcohol or brandy dissolved the colouring matter of saunders much better than water, employed this solution, both alone and mixed with six or ten parts of water, to dye patterns of wool, silk, cotton, and thread, which had been previously prepared by being impregnated with the solution of tin, and afterwards washed and dried. These patterns took all of them alike a poppy colour. Patterns of the same kind prepared with alum, also took a rich scarlet colour; prepared with sulphat of copper, a fine clear crimson colour; prepared with sulphat of iron, a beautiful deep violet.

With the spirituous liquor he dyed in the cold, but employed a gentle degree of ebullition with that which had been mixed with water; this mixture takes place without injuring its transparency.

Soot is likewise employed to give wool a fawn colour, or a brown, which is more or less deep according to the proportion of that substance which is employed; but soot gives only a fading colour, because it only attaches itself feebly to the wool instead of combining with it; it renders it harsh and leaves a disagreeable

smell: it is used however for browning certain colours in some manufactories of eminence; no doubt because certain shades may be obtained by it, which would be difficultly got by other means.

SECTION VI.

Of Compound Colours.

THAT compound colours are formed by the admixture of simple ones, is well known; and if the colouring particles were not liable to vary in their effects, according to the combinations they form, and the influence exerted on them by the different substances contained in the baths, the shade which should result from the mixture of two colours or substances which would produce these colours when unmixed, might be determined with accuracy; but the chemical action of mordants, and of the liquor of the bath, frequently change the results; theory however may be extended to these effects.

We must not consider as a constituent part of compound colours that which is natural to the colouring particles, but that which they ought to assume with a particular mordant, and in a particular bath, so that our attention must be principally fixed on the effects of the chemical agents we employ.

It

It is in this part of dyeing that the knowledge of the artist may be most useful, by enabling him to vary his processes according to the fantastical changes of the fashion, and to arrive at the end proposed in his operations, by the most simple, short, and cheap means.

The processes for compound colours are very numerous. I shall mention only those which have appeared to me most worthy of attention, and shall endeavour more especially to establish by examples, the principles by which we ought to be guided. I have already in the course of the work described many processes for colours which may be considered as compound ones, because I did not think it right to confine myself strictly to a plan, which involved the necessity of separating operations nearly connected with each other.

C H A P. I.

*Of the Mixture of Blue and Yellow,
or Green.*

MANY different plants are capable of affording green colours, such as the field broom-grass (coquiole noire) *bromus secalinus*, the green berries of the berry-bearing alder (bourdaine) *rhamnus frangula*, wild chervil or cow-weed (cerfeuil sauvage) *chærophylum sylvestre*, purple or honeyfuckle clover (le trefle des prés) *trifolium pratense*, common reed (le roseau) *arundo phragmitis*; but these colours are not permanent.

M. d'Ambourney however asserts, that he has obtained a permanent green from the fermented juice of the berries of the berry-bearing alder; he prepared the cloth with tartar, nitrous solution of bismuth, and common salt, and added to the fermented juice of the berries when warmed, a little acetite of lead: the cloth acquired in this bath a middle shade between parrot and grass green.

It is by the admixture of blue and yellow, that the dyers make green, which is distinguished into a great number of different shades; it requires address and experience to obtain this colour uniform and without spots, particularly in the light shades.

Green may be produced by beginning either with the yellow or the blue dye; but the first method is attended with some inconveniencies, for the blue soils the lincn, and a part of the yellow being dissolved in the vat, changes and makes it green; the second method is therefore preferred.

The pastel vat is commonly employed, but for some kinds of green, solution of indigo in the sulphuric acid is used; and then, the blue and yellow are either dyed separately, or all the ingredients are mixed together, to dye by a single operation; finally, solutions of copper with yellow substances may be employed. We shall briefly mention the different processes.

The blue ground ought to be proportioned to the green we wish to obtain; thus for the green, like that of a drake's neck, (*verd canard*) a ground of deep royal blue is given; for parrot green, a ground of sky blue; for *verd naïf-*

fant, a ground of whited blue (*bleu blanchi*) is given.

When the cloths have received the proper ground they are washed in the fulling mill, and are boiled as for common welding, but for the light shades, the proportion of salts is diminished. Most commonly the cloths intended for the light shades are boiled first; and when these are taken out, tartar and alum are added; and this practice is pursued until we come to the cloths intended for the darkest shades, more and more tartur and alum being always added.

The welding is conducted in the same manner as for yellow; but a larger quantity of weld is employed, unless for the lighter shades, which on the contrary require a still smaller proportion. For the most part, a succession of shades from the deepest to the lightest is dyed at the same time, beginning with the deepest and proceeding to the lightest: between each dip, which lasts half an hour, or three quarters, water is added to the bath. Some dyers give each parcel two dips, beginning the first time with the deep shades, and the second with the light ones; in that case each parcel should remain a shorter time in the bath: for
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the very light shades, we must take care that the bath does not boil.

To the very deep greens a browning with logwood and a little sulphat of iron is given.

In silk it is still more difficult to prevent the green from being spotted or striped than in cloth. The scouring of the silk intended for greens, is conducted in the same manner as for common colours; for the light shades however it must be thoroughly scoured as for blue.

Silk is not first dyed blue like cloth, but after being well alumed, it is slightly washed at the river, and divided into small hanks that it may take the dye uniformly; it is then turned carefully in the weld bath. When it is thought that the ground is sufficiently deep, a pattern is tried in the vat, to determine whether the colour is of the proper shade; if it has not ground enough, decoction of weld is added; and when it is certain that the yellow has attained the proper degree, the silk is taken out of the bath, washed, and dipped in the vat as for blue.

To render the colour deeper, and at the same time to vary its hue, decoction of logwood, fustic, or annotta, are added to the yellow bath after the weld has been taken out; for the

very light shades, such as apple and sea-green, a much weaker ground is given than for the others. For all the light shades except sea-green, it is thought best to give the yellow by baths which have been already used, but which contain no logwood or fustic; because silk when completely alumed take the colour too quickly in fresh baths, and is then subject to be dyed unequally.

When raw silk is to be dyed green, that which is naturally white is chosen, as for yellow, and after being well soaked, is alumed and treated in the same way as other silks.

When the blue vat is employed to dye green, saw-wort may be employed instead of weld; it is even preferable, because the colour it gives inclines naturally to green: dyers-broom may also be employed, and sometimes these substances are mixed together; other substances which dye yellow may also be employed, and a variety of shades thus procured.

The green obtained by means of solutions of indigo in sulphuric acid is known by the name of Saxon green; it has more brightness, but less durability, than that above described: this process was first executed in Saxony, and government caused a description of it to be published

published in 1750^a. According to this description, the cloth must be boiled for half an hour with alum and tartar, taken out and aired without being washed; the bath is then to be cooled, and the solution of indigo well mixed with it, adding at first only one half; the cloth is then put in and turned rapidly without boiling for five or six minutes; it is then taken out that the remainder of the solution may be added, which ought to be mixed with great care: after having gently boiled the cloth in it for seven or eight minutes it is taken out and cooled; the bath is emptied to about three fourths, perhaps somewhat more or less, according to the shade of green we wish to produce; it is then filled with a decoction of fustic, and when this bath is very hot, the cloth which had been dyed blue and cooled, is dipped in it, until it has acquired the proper shade. Cloth dyed blue in the bath with alum and tartar, has a less vivid, but more durable colour, than when it is dyed blue in a bath with water, without any other addition.

Experience has taught a more expeditious and even a more certain mode of conducting this process; a boiling is given as for welding,

^a Maniere de teindre un drap blanc en verd, nommé verd de Saxe.

and the cloth is then washed, fustic in chips enclosed in a bag, is put into the same bath, and boiled for an hour and a half, then taken out and the bath cooled to a temperature which the hand can support; nearly a pound and a quarter of the solution of indigo for each piece of cloth of eighteen ells which is to be dyed, is then added; at first it is to be turned with rapidity, and afterwards slowly; the cloth is to be taken out before the bath boils. It is a proper practice to put in only two thirds of the solution at first, to take out the cloth after two or three turns, and then to add the last third; the colour is thus rendered more uniform; if it is observed that the colour does not take well, a little calcined alum reduced to powder is added. The faxon apple green is dyed in the bath which has served for faxon green, after one third or one half of it has been taken out, and after it has been cooled; the cloth is turned in it until it is near boiling.

It is easy to perceive, that a great variety of greens may be produced, not only according to the proportions of the indigo and yellow dye employed, but according to the nature of the yellow substance, which may affect the green, both as to shade and fixity; and the colour may be still further modified by reactives.

M. Pocerner

M. Poerner thus obtains a great variety of shades by means of a solution of indigo in the sulphuric acid, to which he adds pot-ash, and which has been described in treating of indigo. He prepares a pound of cloth, by boiling it two hours with two ounces and a half of alum, and leaves it for twenty-four hours in the bath after it has grown cold; he then boils it for an hour, in a bath made with five ounces of weld; after which he adds two ounces and two drams of the indigo dye, makes the bath boil a quarter of an hour, redips the cloth which he had taken out, and boils it again for an hour. It thereby acquires a light green colour inclining to yellow. To make the colour more of a green, M. Poerner adds to the bath either tartar, which weakens the yellow colour, or sulphat of lime, which renders it deeper, or sulphat of copper or verdegris; he also increases the quantity of solution of indigo as far as two ounces and a half; sometimes he increases the quantity of the weld. By these means, several of which he sometimes unites together, he obtains greens, in which the yellow or the blue are more or less predominant, and which are more or less deep. He employs the same processes with many other yellow ingredients, such as saw-wort, broom, fustic, &c.

and

and each of these substances likewise produces varieties.

According to M. Gühliche, three yellow substances may be employed for dyeing silk of a faxon green; turmeric, fustic, and french berries.

The greens obtained by means of turmeric are the most beautiful, but the most fading. The silk is alumed in the proportion of four ounces of alum to the pound, being left twelve hours in the solution when cold: a bath is prepared with an ounce of pounded turmeric, to which as much solution of indigo in sulphuric acid as will give it a sufficiently green colour is added; an ounce of solution of tin is then mixed with it, and the alumed silk dipped until it has acquired a fine green colour, when it is wrung, washed, and dried in the shade.

When french berries are used, a more beautiful colour is obtained by employing the tincture made with the aceto-citric acid, as already mentioned: as the bath is acid, only two ounces of alum are employed in aluming each pound of silk; in other respects, the process is conducted like the former. The shades may be varied by the proportions of the solutions of indigo. If the blue prevails, a sea green

green is produced. The light shades may be dyed after the deep ones.

It is mentioned as a fault in the faxon blue, that it has a greenish cast, which is probably owing to the slight alteration produced in the particles of indigo by the sulphuric acid; it is also said to be a fault in faxon green, that it has less durability than the blue and green produced by means of the vat. It has been attempted in England, to obtain the brightness which characterizes the faxon blue and green, avoiding the faults which accompany it, and uniting the advantages of the blue of the vat, and those of the solution of indigo in the sulphuric acid. M. Gühliche describes a process for giving silk the english blue and green. I have judged it proper here to unite these two objects together.

M. Gühliche describes a cold vat which he employs for dyeing silk blue, and which he highly extols for convenience and cheapness, as well as for the beauty of the colours it produces.

This vat is composed of a pound of indigo, three pounds of good quick lime, or lime flacked by the air, three pounds of english vitriol, and a pound and a half of orpiment. The indigo should first be carefully ground and mixed with water, put into a wooden vat
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and diluted with water to a proper degree, according to the intensity of the colour we wish to obtain; the lime is then to be added, and the mixture well stirred, covered up, and left at rest for some hours, when the vitriol reduced to powder is to be added, the whole well stirred, and the vat covered; some hours after, the orpiment in powder is to be thrown in, and the whole again left at rest for some hours; after this, the mixture is to be stirred, and left to settle until the supernatant liquor appears clear, when the flower which covers it is put aside; the silk is then dyed hank by hank, after having been previously dipped in warm water. When taken out of the bath, it is washed in a stream of water and dried. When the bath becomes turbid, it is left to settle till it grows clear, a precaution essentially necessary for the light shades, and when it begins to be exhausted, one third of the ingredients are added, proceeding as at first. In proportion as the vat is exhausted, the shades become lighter. This vat serves equally well for silk, thread, and cotton. M. Gihliche is of opinion, that those who have not succeeded in dyeing silk in the cold vats, or who complain that only weak shades are thus obtained, have been led into an

error by having employed too small a quantity of orpiment ^b.

For english blue, it is necessary first to give silk a light blue : when taken out of this bath, it is dipped in hot water, washed in a stream, and left in a bath composed of the solution of indigo in the vitriolic acid, to which a little solution of tin has been added, until it has acquired the proper shade, or has exhausted the bath : before it is put into this bath, it may be dipped in a solution of alum, in which it must not be suffered to remain too long. Silk dyed in this manner has neither the reddish cast given by the blue vat, nor the greenish cast of the faxon blue.

To make english green, which is more beautiful than common green, and more durable than faxon green, Mr. Guhliche first gives the silk a light blue in the cold vat, soaks it in warm water, and washes it in a stream, dips it in a weak solution of alum, prepares a bath with the solution of indigo in sulphuric

^b For wool Mr. Guhliche employs a vat composed of one pound of indigo, four pounds of pot-ash, one pound of lime, and a pound or a pound and a half of orpiment. The process is the same, except that he keeps this last vat at a moderate degree of heat. He employs it also in the same way to give english blue and green to cloth.

acid,

acid, an ounce of solution of tin, and the tincture of french berries already described : in this bath the silk is kept until it has taken the desired colour, when it is washed and dried in a shady place ; the lighter shades may be dyed afterwards. The shades are rendered more or less blue, or more or less yellow, according to the proportions of the yellow substances and solution of indigo. When a gosling green (*verd d'oie*) is to be given to silk, it is first dyed of a light blue, either in the hot or cold vat, then passed through hot water, and washed in a stream, and while still moist, dipped in an annotta bath.

To give a green colour to linen and cotton thread, they are first scoured, dyed in the blue vat, cleansed and dipped in the weld bath. The strength of blue and the yellow is proportioned to the colour we wish to obtain. As it is difficult to dye cotton velvet uniformly in the common blue vat, it is first dyed yellow with turmeric, and finished green with the solution of indigo in the sulphuric acid. It is a matter of indifference whether we begin with the yellow or the blue.

Mr. Pileur d'Apligny describes a process for dyeing cotton velvet, or skeins of cotton, of a sea or apple green in a single bath.

Verdegris

Verdegris is mixed with vinegar, and the mixture kept well stopped fifteen days in a stove; four hours before using it, a solution of a quantity of cendres gravelées equal in weight to that of the verdegris is added, and the mixture is kept hot. The cotton, thread, or velvet are prepared, by being soaked in a warm solution of alum, made in the proportion of one ounce of salt, and five quarts of water to the pound, they are then taken out, and the verdegris mixture added to the bath, into which they are returned in order to be dyed.

All the shades of olive, and drake's-neck green, are made by giving the thread a blue ground, galling it, and dipping it in a weaker or stronger bath from the black cask, then in the weld bath with the verdegris, and afterwards in the bath with the sulphat of copper; and lastly, the colour is brightened with soap.

A green colour may also be given to cotton which has been dyed blue with prussian blue, by the process described, Sect. II. Chap. V. of the second part; the piece while still wet with the blue, is alumed^c and dipped in a weld bath, which is stronger or weaker according to

^c L'art du fabricant de velours de coton.

the shade required. Weld produces a more lively colour than fustic, which gives a deeper shade and diminishes the brightness of the blue ; if a green inclining to olive be required, fustic is preferable. It is dried in the open air as for blue.

There is nothing obscure in the formation of the green, produced by giving a yellow colour to a stuff previously dyed blue and washed. The colour inclines more or less to yellow or to blue, according to the depth of the blue shade, and the strength of the yellow bath. The intensity of the yellow is increased by alkalis, sulphat of lime, and ammoniacal salts ; it is diminished by acids, alum, and solutions of tin. The shades also vary according to the nature of the yellow substance employed.

Different effects will be produced by the same ingredients in the formation of saxon green, according to the process which is employed : if a saxon blue be first given, and afterwards the yellow colour, separately, the effects will be similar to those just mentioned ; but if the solution of indigo be mixed with the yellow ingredients, other results are obtained, for then, the sulphuric acid acts on
the

the colouring particles and diminishes the intensity of the yellow.

When a succession of shades are dyed in a bath composed of yellow and the solution of indigo, the last approach more and more to yellow, because the particles of indigo become attached to the stuff in preference to the yellow ones, which are therefore rendered predominant in the bath.

Although sulphat of copper and even verdgris, which is sometimes employed, chiefly to dye thread and cotton, have a blue colour, yet they give the stuff a greenish colour, because the oxyd of copper which is attached to it, acquires that colour by combining with a larger quantity of oxygen; for it has been shewn in the first part, that the colour of this oxyd changes from blue to green, according to its quantity of oxygen. This colour is made to incline to an olive hue by means of a yellow substance.

C H A P. II.

Of the Mixture of Red and Blue.

BY the mixture of red and blue, we obtain violet, purple, dove colour, pansy, amaranth, lilac, mauve, and a great number of other shades, determined by the nature of the substances, the red colour of which is combined with the blue; by the proportion of these substances, and the different steps of the process.

According to Hellot's observations, stuff which has been dyed scarlet, takes an unequal colour when blue is to be united with it. The blue is therefore given first, which, even for violet and purple, ought not to be deeper than the shade distinguished by the name of sky-blue, a boiling is given with alum mixed with two fifths of tartar, the stuff is then dipped in a bath composed of nearly two thirds as much cochineal as for scarlet, to which tartar is always added. The circumstance which distinguishes the process for purple from that for violet, is, that for the former, a lighter

lighter blue ground is given, and a larger proportion of cochineal is employed. These colours are frequently dyed after the reddening for scarlet, such quantities of cochineal and tartar being added as are thought necessary. The operation is conducted in the same manner as for scarlet.

Lilacs, pigeons necks, mauves, &c. are commonly dipped in the boiling which has served for violet, after alum and tartar have been added to it: the blue ground having been proportioned to the shade required, the quantity of cochineal is also adjusted in a similar manner: a little solution of tin is added for some reddish shades, such as peach blossom. It must be observed, that though the quantity of cochineal is diminished according to the lightness of the shade required, the quantity of tartar is not lessened, so that the proportion of it compared with that of the cochineal, is so much the greater, as the colour required is lighter.

Mr. Poerner is of opinion, that to obtain the colours composed of red and blue, it is advantageous to employ the solution of indigo in sulphuric acid, because a great variety of shades is thus more easily procured, and the process is shorter and less expensive. The

colours obtained in this way are indeed much less durable than when the blue vat is employed; but Mr. Poerner asserts, that they possess durability, when solution of indigo to which alkali has been added is employed.

He prepares a pound of cloth with three ounces of alum, by boiling it for an hour and a half, and leaving it a night in the liquor after it is cold. He makes the bath with an ounce and a half of cochineal, and two ounces of tartar, boiling it for three quarters of an hour, and then adding two ounces and a half of solution of indigo, he stirs it, and makes it boil gently for a quarter of an hour: he thus obtains a very beautiful violet.

For the different shades which result from the mixture of red and blue, according as one or other of the colours prevails, he increases or diminishes the proportion of the solution of indigo; he increases it as far as five ounces, and diminishes it to five drams for each pound of cloth: he also reduces the quantity of cochineal, but never below an ounce, because the colour would become too dull: he changes the proportion of tartar, and finally, he varies the preparation given to the cloth, by the addition

addition of tartar or solution of tin in different quantities.

In silk, two kinds of violets are distinguished, the fine and the false : the last is made either with archil or brasil-wood.

For the fine violet, the stuff is first passed through cochineal, and afterwards dipped in the vat ; the silk is prepared and dyed in the cochineal in the same manner as for crimson, except that neither tartar nor solution of tin, which serve to heighten the colour, are employed. More or less cochineal is used, according to the intensity of the shade required. The common proportion for a fine violet, is two ounces for each pound of silk. When the silk is dyed, it is washed at the river and beetled twice, then dipped in a vat of greater or less strength, according to the depth we wish to give the violet ; finally, it is washed and dried with the precautions which are proper for all colours dyed in the vat. To give greater strength and beauty to the violet, it is commonly passed through the archil bath ; and this custom, which is frequently abused, is indispensable for the light shades, the colour of which would otherwise be too dull.

When the filk has been dyed with cochineal as above directed, a very light blue shade must be given it for purple : only the deepest shades are dipped in a weak vat ; such as are less deep are only dipped in cold water, into which a little of the liquor of the vat has been put, because they would take too much blue in the vat itself, though ever so weak. The light shades of this colour, such as gilly-flower, gridelin, and peach blossom, are made in this way, by diminishing the proportion of cochineal.

The false violets in filk are produced in many different ways ; those which are most beautiful and most in use, are prepared with archil. The strength of the archil bath is adapted to the colour we wish to obtain ; the filk is turned in it on the skein sticks, after having been beetled at the river after scouring : when the colour is thought to be sufficiently deep, a pattern is tried in the vat, to see whether it takes the violet we wish for. If the shade is found to be of the proper depth, the filk is beetled at the river and dipped in the vat as for the fine violets ; less of the blue, or less of the archil colour are given, according as we mean that the violet should incline to red or blue.

According to Mr. Gühliche, beautiful violets may be produced in silk by means of the solution of indigo; but they possess little durability and become reddish, because the colour of the indigo fades first.

A pound of silk is soaked in a bath composed of two ounces of alum and two ounces of solution of tin, after being decanted from the sediment formed in the mixture. The dye bath is prepared with two ounces of cochineal (reduced to powder with a dram of tartar) and the remainder of the bath which has served as mordant, with the addition of a sufficient quantity of water; after being slightly boiled, such a quantity of solution of indigo is added, as gives the bath a proper shade of violet; the silk is then immersed, and boiled until it has acquired the proper shade, when it is wrung, washed in a stream, and dried in the shade, like all delicate colours. The bath is exhausted by the light shades.

A violet is given to silk, by dipping it in water with which verdigris has been mixed, instead of aluming it; and then giving it a bath of logwood, where it assumes a blue colour, which is changed to violet, either by adding alum to the bath, or by dipping it in a weaker or stronger solution of alum, which gives

gives the particles of logwood a red colour. It is unnecessary to observe, that this violet is of a very fading nature, and only a moderate degree of beauty ; one possessing much greater beauty, and to which a considerable degree of intensity may be communicated, is made by dipping the alumed silk in a bath of brasil-wood, and again, after it has been washed at the river, in a bath of archil. Madder is also employed in dyeing cloth, after it has had a blue ground ; couleur de roi, minime, and obscure amaranth, are thus obtained ; galls are commonly added to the madder, and for the light shades, brasil-wood ; for the deep shades, more or less browning is given, with a solution of sulphat of iron. These colours are rendered more beautiful by the addition of kermes, or more especially of cochineal.

By employing solution of indigo with madder, in the same way as with cochineal, we may, according to Mr. Poerner, obtain brown colours inclining the more to red, the less solution of indigo we employ ; alum and tartar may serve for the preparation, but alum must not be put into the bath.

Mr. Poerner employs brasil-wood and solution of indigo, to obtain different colours, which incline more or less to blue and red,
by

by a process similar to that pointed out for cochineal and madder. These are beautiful, but durability cannot be expected in colours obtained by such means. The substances which render them most fixed, are sulphat of lime, sulphat of zinc, or white vitriol, and acetite of copper, or crystallized verdegris, which must be added to the bath.

Logwood is also employed to make floc, damascene, purple, and other shades. This wood with the addition of galls, very easily communicates all these colours to wool previously dyed blue. When we wish to brown them, a little sulphat of iron is employed, and by these means we produce shades, which are much more difficultly obtained from durable ingredients, but they possess little stability: durable colours which have been highly esteemed, have however been obtained from brasil and logwood. I am indebted to Mr. Decroizille, who is occupied in the arts with all the knowledge of a well-informed chemist, for the following particulars of the process employed, of which the descriptions given have been inaccurate.

“ Mr. Giros de Gentilly is the first who
“ succeeded in France, in obtaining a durable
“ dye from violet wood fixed by solution of
“ tin.

“ tin. His first essays were made at Louviers,
“ with Messrs. Petou, Nephew, and Frigard,
“ about twelve years ago. From what he
“ had suffered to transpire respecting the sub-
“ stances which composed his mordant, I
“ succeeded in imitating him tolerably well.
“ I made a solution of tin in sulphuric acid,
“ to which I then added muriatic soda, red
“ acidulous tartrate of pot-ash, and sulphate
“ of copper. My success was so great as to
“ induce Mr. Giros to offer me a partnership
“ in the very lucrative trade in this article,
“ which he carried on at Louviers, Elbocuf,
“ Abbeville, Sedan, and the Pays de Liege.
“ Mr. Giros then taught me a much more
“ convenient mode of forming this compound ;
“ it consists in making a solution of tin in a
“ mixture of sulphuric acid, muriatic soda,
“ and water ; to this solution, the tartrate and
“ sulphate are added, in the form of powder.
“ Of this mordant we made no less than
“ fifteen hundred quarts in twenty-four hours,
“ in a single leaden vessel moderately heated.
“ We carried on a very profitable trade in
“ this article at the rate of thirty sols (fifteen-
“ pence Eng.) per pound for three years, since
“ which time it constantly declined, until we
“ lost it altogether ; the reason of which was
“ this :

“ this : Mr. Giros having suffered his secret
“ to transpire, we had a number of imitators,
“ who at first succeeded in a less degree, but
“ afterwards better than ourselves. In a com-
“ pound consisting of so many ingredients as
“ this, in an operation which is still so obscure
“ as that whereby colours are fixed, it is almost
“ impossible to arrive at perfection, by any
“ other means than random trials, which may
“ be infinitely varied by the different propor-
“ tions, and more especially by the *modus*
“ *agendi*, and to a much greater extent, than
“ chemists who had bestowed less time on this
“ subject than I have done, would suppose.
“ I am therefore not ashamed to confess that
“ I was forced to abandon the business, while
“ I saw, and still see, those who are no che-
“ mists deriving a very comfortable profit from
“ it. What determined me to abandon it
“ altogether, was the invention of the new
“ process for bleaching linen, to the improve-
“ ment of which I have almost entirely de-
“ voted myself.

“ Having given you the history of the
“ mordant for the *prune de Monsieur*, I shall
“ mention the mode of employing it and its
“ effects.

“ If

“ If it is wool in the fleece which is to be
“ dyed, one third of its weight of mordant is
“ required ; if it is a stuff, only one fifth is
“ necessary. A bath is prepared of a degree
“ of heat which the hand can bear, with
“ which the mordant is well mixed, and the
“ wool or stuff dipped in it and properly
“ stirred, the same degree of heat being kept
“ up for two hours, and even increased a little
“ at last ; it is then taken out, aired, and
“ very well washed : a fresh bath of pure
“ water at the same heat is prepared, a suffi-
“ cient quantity of the decoction of violet
“ wood is added ; the stuff immersed, stirred,
“ and the fire increased to a boiling heat,
“ which is continued for a quarter of an hour :
“ the stuff being then taken out, aired, and
“ carefully rinsed, the dyeing is finished. If
“ the decoction of one pound of violet wood
“ of Campeachy, has been employed for three
“ pounds of wool, and a proportionate quan-
“ tity for stuffs, which require less, a fine
“ violet is produced, to which a sufficient
“ quantity of brasil-wood gives the shade com-
“ monly known by the name of *prune de*
“ *Monsieur*.

“ The colouring substances which are capa-
“ ble of being advantageously fixed on wool
“ by

“ by this mordant, are those of violet and red
“ wood (logwood and brafil), and fustic (bois
“ de fustet). Bois jaune (*morus tinctoria*)*,
“ also affords tolerable colours. The colour
“ which is thus given by violet and red wood
“ is liable to be changed in the fulling, by
“ means of the soap or the urine employed,
“ and this change, which is always produced by
“ alkaline substances, is remedied by a bath
“ very slightly acid and a little hot, called
“ *brightening*, for which the sulphuric acid is
“ preferred. The colour comes out as deep
“ and often brighter than before the change.
“ Wools dyed by means of this mordant, admit
“ of being spun into a more beautiful and
“ finer thread, than when alum has been em-
“ ployed. By leaving out the sulphat of
“ copper, more beautiful colours are obtained
“ from fustic and yellow wood, as well as
“ from weld. Madder gives an orange red
“ colour, but less deep than with an equal
“ quantity of alum; the omission of the sul-
“ phat of copper renders the wool much more
“ harsh, and besides, the mordant thus prepa-
“ red gives but indifferent colours with violet
“ and more especially with red wood. One

* Vid. notes to pages 268 and 281.

“ of the great defects of this mordant before
“ it was improved, was, and frequently still is,
“ to render the colours uneven; whenever
“ they are uniform, they turn out always very
“ beautiful, harmless, and soft. This process
“ succeeds equally well on silk. By substi-
“ tuting acetite of lead for sulphat of copper,
“ it succeeds tolerably well in cotton and
“ thread previously galled; the employment
“ and carriage of this mordant are inconve-
“ nient, on account of the heavy sediment
“ which half fills the vessel under a corrosive
“ liquor which can only be kept in stone ware.
“ I have however, found a remedy for these
“ inconveniences, by omitting the water in
“ the receipt; by which means I have only a
“ kind of paste, the use of which is more con-
“ venient, and the carriage two fifths cheaper.
“ Now that muriat of soda is cheap, I may
“ possibly return to the employment of fur-
“ nishing our dyers with this mordant, of a
“ better quality, in my opinion, than that
“ with which they are supplied, and more
“ especially, at a much cheaper rate; but
“ I must first devote some more time to the
“ composition and employment of your lix-
“ ivium.”

The most common method of dyeing thread and cotton, violet, is first to give them a blue ground in the vat, proportionate to the shade we want, and to dry them; they are then galled, in the proportion of three ounces of galls to a pound: they are left for twelve or fifteen hours in this gall bath, after which, they are wrung and dried again. The thread and cotton are then passed through a decoction of logwood, and when well soaked are taken out, and two drams of alum, and one dram of dissolved verdgris for each pound of thread and cotton, are added to the bath; the skeins are then redipped on the skein sticks, and turned for a full quarter of an hour, when they are taken out to be aired; after which they are again completely immersed in the bath for a quarter of an hour, then taken out and wrung. Lastly, the vat which has been employed is emptied; half of the decoction of logwood which had been reserved is poured in, two drams of alum are added, and the thread dipped afresh, until it is brought to the shade required. The decoction of logwood ought to be stronger or weaker according to the shade we want: this violet stands the action of the air tolerably well,

but cannot be compared in durability to that obtained by means of madder, which will be described in the fourth chapter of this section.

In the production of violet by cochineal, it may be observed, that the woollen stuff has been disposed to take a crimson, by the bath, which contains alum ; but the tartar added to the dye bath, brings the colour back to red ; this is a general property of all acids.

For purple, the red is rendered a little more predominant, by increasing the quantity of the cochineal, and diminishing the intensity of the blue ground.

The shades bordering on these two colours should have a more distinct red, and the same proportion of tartar is preserved, though that of cochineal and the depth of the blue ground are diminished.

For silk, the tartar is omitted ; it naturally acquires from cochineal a colour, to which it is only necessary to add a slight blue shade to produce purple ; a deeper blue shade gives a violet colour, but to increase the fulness of the violet and give it brightness, archil must be employed.

When

When solution of indigo in sulphuric acid is used, the sulphuric acid acts in different ways on the red substance employed ; it produces little change in the colour of cochineal, already disposed to a crimson tinge by the aluming ; but it should give a fawn colour to madder, upon which acids readily produce this effect, and it does not seem probable, that that substance could be employed with advantage in this process ; it is better to employ it in dyeing stuff, which has already received a blue ground. Brasil and logwood too seem ill adapted to produce fine colours with the sulphuric solution of indigo, because acids also change them yellow, though in a less distinct degree ; but they retain their red colour, as already observed, when their colouring particles are precipitated by oxyd of tin.

Were it allowable to hazard an opinion, without being guided by any direct experiments, on so complicated a process as that communicated by Mr. Decroizille, I should endeavour to explain it in the following manner.

The sea salt is decomposed by the sulphuric acid, and the muriatic acid thus set at liberty,

dissolves the tin; a part of the tin is precipitated by the acid of tartar, producing the sediment which has been noticed. The oxyd of copper forms the blue with the colouring particles of the logwood; the oxyd of tin produces violet with the same wood, and red, with the colouring particles of the brazil-wood.

As the liquor retains an excess of acid, it might perhaps be useful to substitute acetate to sulphate of copper, because then, the free acid would have less activity; perhaps it might be still better to employ verdigris, because that part of the oxyd of copper which is uncombined in it, would unite with the excess of acid, by which means, less acid would remain in the liquor; perhaps the quantity of tartar should be diminished, because less of the tin would then be precipitated.

C H A P. III.

Of the Mixture of Red and Yellow.

WHEN treating of cochineal I thought it would be improper to separate operations which commonly succeed each other in the dye-house, and have therefore described the principal shades obtained by the mixture of the red of cochineal with yellow. These shades may be infinitely varied by the different proportions of the ingredients, by the yellow substances made choice of, by the preparations given to the cloth, and by the mordants added to the dye bath. Thus, Mr. Poerner describes a great many varieties, which he obtained by using weld, saw-wort, dyers-weed, and other yellows, and by employing in the preparation of the cloth, or in the bath, tartar, alum, sulphat of zinc, or sulphat of copper.

In like manner, various colours may be obtained from madder united with yellow substances. It is in this way, that mor-doré and cinnamon colours are produced; these colours are commonly made in two baths. We begin

by the maddering, preceded by a boiling with alum and tartar, as for the common maddering, and then give a weld bath.

For cinnamon colours, the maddering is weaker, and a bath which has served for mordoré is commonly employed. The proportions are varied, according as we wish that the red or yellow should prevail; sometimes galls are added, and sometimes the colour is darkened by a browning.

Mr. Poerner obtains many colours from madder mixed with saw-wort; he prepares the cloth with different mordants, but more especially with alum and tartar; he also adds alum and tartar to the bath. When the quantity of either of these salts is considerable, the colour has an orange cast, because acids give the colour of madder a yellow hue; but if their quantity be but small, a reddish yellow is obtained. Mr. Poerner has procured reddish brown colours, by putting sulphat of zinc or white vitriol into the dye.

Sometimes it is only intended to give a reddish hue to yellow; in that case the stuff immediately after being dyed yellow, may be passed through a madder bath of different degrees of strength according to the end proposed.

Brasil-wood is also employed with yellow substances, and sometimes it is mixed with cochineal and madder.

When instead of weld or other yellow substances, walnut-tree root, walnut-peels or sumach are employed, snuff, chefnut, musk colours, &c. are obtained.

Marrones, cinnamons, and all the intermediate shades are given to silk, by logwood, brasil, and fustic.

The silk is scoured as usual, alumed, and a bath prepared, by mixing decoctions of the three above-mentioned woods made separately; the proportion of each is varied according to the shade required, but that of the fustic ought to prevail; this bath should be of a moderate temperature. The silk is turned on the skein sticks in the bath, and when it is taken out, if the colour be uniform, it is wrung and dipped in a second bath of the three ingredients, the proportions of which are regulated according to the effect of the first bath, in order that the proper shade may be produced.

Cinnamon and mor-doré colours are given to thread and cotton, by beginning the process for dyeing them with verdgris and weld; they are then dipped in a solution of sulphat of iron, called *bain d'assurage*, wrung and dried. When dry,

they are galled in the proportion of three ounces of galls to the pound, dried again, alumed as for red, and maddered. When dyed and washed they are put into very warm soap suds, and turned until they are sufficiently brightened; decoction of fustic is sometimes added in the aluming.

The mixture of red and yellow affords no particular observations, in addition to those contained in the two last chapters.

For some colours, blue is united to red and yellow; it is thus that olives are made. A blue ground is first given, then the yellow dye, and lastly, a slight maddering. The shade which results from this operation depends on the proportion of the three colours of which it is composed; for the deep shades, a browning is given with a solution of sulphat of iron.

Mr. Poerner combines blue with yellow and red, by employing the solution of indigo in the sulphuric acid, to which he adds alkali, as already mentioned. He prepares a bath with cochineal and fustic, adds the solution of indigo, and dyes the cloth in it after it has been alumed. He also makes a bath with fustic and brasil-wood, to which he adds tartar or alum, and thus obtains different colours inclining more or less to blue, red, or green.

The blue vat is not employed to produce olives in silk, which, after the aluming, is dipped in a very strong weld bath; to this, juice of logwood is afterwards added, and when the silk is dipped, a little solution of alkali is put in, which turns it green, and makes the silk take an olive colour. The silk is dipped in this bath afresh, until it has acquired the proper shade. For the colour which is called *olive rousse*, or rotten olive, fustic and logwood, but no alkali are added to the bath after the welding: if it is intended, that the colour should have more of a red cast, only logwood is added. A kind of reddish olive is also made, by dyeing the silk in a bath of fustic, to which more or less sulphat of iron and logwood have been added.

According to M. le Pileur d' Auligny, a fine olive is given to thread and cotton, by boiling four parts of weld and one of pot-ash in a sufficient quantity of water; brasil-wood which has been steeped over night, is boiled separately with a little verdgris; these two solutions are mixed in different proportions according to the shade required, and the cotton or thread are dipped in them,

C H A P. IV.

Of Shades which result from the Mixture of Black with other Colours, and of Brownings.

I HAVE described the processes whereby we obtain black, which constitute the different shades of gray ; I have shewn, that other shades of a different kind might be mixed with them, so as to make them incline towards certain colours ; but black is often mixed with other colours which are to remain predominant : it is only wished that they should be browned, and at the same time acquire greater durability. In the course of this work I have sometimes mentioned that a browning was given to certain colours ; but in the present chapter I shall treat particularly of this operation, and of the resources which it affords to the art, sometimes for the purpose of imitating colours which may be obtained by other means, sometimes for the production of new colours.

To give a browning, stuff which has been just dyed, is dipped in a solution of sulphat
of

of iron to which an astringent has been added, and which consequently forms a *black bath*; more frequently, a small quantity of solution of iron is mixed with a bath of water, and more is added, till the dyed stuff dipped in it, has attained the shade required: more rarely, sulphat of iron is added to the dye bath, but the desired effect is obtained with greater precision, by dipping the dyed stuff in a solution of sulphat of iron. Mr. Poerner frequently soaks the stuff in a solution of sulphat of iron, to which he sometimes adds other ingredients, and when taken out of this mordant, he dips it in the dye bath.

The first method is employed for marrones, coffee, damascene colours, and other shades of browns of the common dye; a more or less deep colour is given them, according to the shade we wish to obtain by the browning; a bath is then made with galls, sumach, and alder bark, with the addition of sulphat of iron. The stuffs intended for the lightest shades are dipped first; and when they are finished, the browner ones are dipped, a quantity of sulphat of iron proportionate to the end proposed, being added for each operation.

The other brownings have nothing peculiar in the process: I shall select some examples of
of

of the effects produced, and point out some particular processes.

We have seen in the first section of this second part, that for several kinds of gray, a slight blue ground was given. Mr. Poerner makes blueish grays, by employing the solution of indigo in sulphuric acid, which he adds to a mixture of decoction of galls and sulphat of iron, varying the shades by the different proportions of these three ingredients; he obtains other shades, by adding sulphat of iron to a bath composed of cochineal, fustic, and galls.

For couleur de roi, a sky blue ground is given with pastel, the dye is given with weld and one sixth of galls, and the browning, with solution of sulphat of iron.

Marrone, and the colours which border upon it, are made with saunders, galls, and a browning, and sometimes logwood is added: these colours are sometimes made to incline towards purple and crimson, by dyeing them in the remains of a cochineal bath, or by putting a little madder or cochineal into the bath; the colour is rendered lighter by a little tartar.

For hazel colours, galls, fustic, and logwood are mixed, and more or less madder, and a little alum are added.

M. Guhliche employs cochineal and the solution of iron already described*, to produce
a violet

* A description of the solution of iron employed by M. Guhliche, has been given at page 24 of this part; it is a black dye bath, for a black colour may be obtained from it, without the use of other ingredients. M. Guhliche, in the fourth volume of his work, describes the manner in which he employs this solution, in order to produce blacks and grays, in wool and silk. He soaks the wool in a solution of iron, either hot or cold, and then dips it in a bath composed of solution of galls in white wine, and of sumach; he sometimes employs logwood alone, or mixed with a solution of galls and sumach, and sometimes with a little madder; he sometimes begins by soaking it in the solution of iron, and afterwards dipping it in the astringent bath: he also employs his solution alone; but then he does not mix that which is made with rice, with that made with vinegar, and he passes the wool from one solution to the other, either steeping it in the cold, or boiling and drying it between the two immersions: if he does not find the black sufficiently deep, he adds a little solution of galls to the two baths.

He impregnates silk with a solution of galls in white wine more or less diluted with water; in this, it is left to soak for twelve hours, then dried, and put into the solution of iron in the cold, where it is suffered to remain till it has acquired a proper black; he sometimes mixes logwood juice with the solution of iron, and keeps the galled silk in it, making it boil a little towards the end. He also makes use of the solutions of iron in the rice water and vinegar, without mixing them; he begins by macerating his silk in the first, cold, then dries and soaks it in the second: these immersions he repeats, if the first operation has not given
a sufficiently

a violet which indeed inclines to brown but possesses great durability. He alums a pound of woollen stuff in a solution of two ounces of alum; he makes a bath with an ounce of cochineal, and adds an equal quantity of solution of iron, in which he keeps the stuff, until it has acquired a proper shade. Lilacs may be dyed with the remainder. If a colour with less of a brown cast be required, a small quantity of solution of iron is employed, and an ounce of nitre is added.

Brasil-wood, the colour of which has been extracted by means of the aceto-citric or nitro-muriatic acid, may be employed in the same manner.

To obtain puce colour from madder, M. Gihliche gives a pound of woollen stuff a boiling, composed of two ounces of alum, a certain quantity of vinegar and solution of iron, and after a quarter of an hour's ebullition, he leaves it twelve hours in the mordant; he makes a bath with the decoction of two ounces of white galls poured off clear from the sediment, with which four ounces of good madder

a sufficiently deep black: the remains of all these baths are employed for the lighter shades, either separately or mixed together.

are

are mixed, and when it begins to grow hot, he dips the stuff, when taken out of the mordant, and suffers it to remain there, gradually increasing the heat, until it has taken the desired colour; it is then boiled for two minutes, washed and dried in the sun. The colour obtained by this process is very durable. If the alum and vinegar of the mordant be omitted, a deeper brown is obtained: after these colours the lighter shades are dyed. Sumach may also be substituted for one half of the madder.

Brasil and logwood employed in equal quantities, or in other proportions, give different brown colours of tolerable durability, when, more or less solution of iron is mixed with a decoction of them, and the wool previously alumed and galled, is dyed in it; these colours however cannot vie with the former, in durability.

Different shades of mor-doré and capucine may be given to the above colours, by dipping them in a bath of annotta as soon as they are taken out of the dye.

M. Gühliche gives silk a purple violet, without a blue ground; for this purpose, he mixes one part of solution of galls in white wine, with three parts of water, in which he macerates a pound of silk for twelve hours, soaks it

it in a mordant, composed of two ounces of alum, one ounce of solution of tin, and half an ounce of muriatic acid; after it has been wrung, he dyes it in a bath prepared with two ounces of cochineal and a little solution of iron, until it has taken the desired shade: for dyeing lighter shades, the residua of these baths may be used, either separately or mixed together.

He employs madder in the same way, macerating for twelve hours a pound of silk in a solution of two ounces of alum mixed with an ounce of muriatic acid, and a certain quantity of solution of iron; when wrung, he dyes it in a bath prepared with eight ounces of madder. If he wishes to obtain deeper colours, he adds to the madder and cochineal baths some of the solution of galls in white wine.

He also dyes silk, soaked in a solution of two ounces of alum and an ounce of muriatic acid, in a bath composed of equal parts of brazil and logwood juice, with the addition of a certain quantity of solution of iron; and to render the colour deeper, he adds solution of galls.

To make these colours incline to mor-doré and capucine, he sometimes adds solution of tin to the above baths.

He makes brick colours, by dipping the silk, prepared with solution of galls mixed with a certain quantity of solution of iron, in an annotta bath.

A great variety of shades are obtained by the mixture of brasil, logwood, archil, and galls, and by a browning with sulphat of iron; but all these shades are more or less disposed to fade, though they have an engaging brightness.

The black bath distinguished by the name of black cask, (*tonneau noir*) is employed to give thread and cotton a great number of dark colours, of which I shall now mention a few instances.

To give a durable violet to thread and cotton, they are scoured in the usual way; a mordant is prepared, composed of two quarts of the bath of the black cask, and four quarts of water per pound; this is made to boil, and the scum which forms on its surface is removed; when no more appears, the liquor is poured into a vat, and when it is just warm, four ounces of sulphat of copper and an ounce of salt petre are dissolved in it; the skeins are then left in it to soak for ten or twelve hours, wrung and dried. When they are to be maddered, they are carefully washed and dipped in a madder bath. If a deep violet is required, two ounces of verdegris are added to the bath; the colour

is rendered still deeper by galling the thread more or less, before it is put into the mordant, and by omitting the salt petre; if the proportion of this last be increased, and that of the sulphat of copper be diminished, the violet inclines more to lilac. The mordants may also be modified in different ways, so as to produce a great number of shades.

For the different shades of marrone, cotton is galled, dipped and worked in the usual manner, in a bath, to which more or less of the liquor of the black cask has been added; it is then washed in a bath, with which verdegris has been mixed, welded, and dyed in a bath of fustic, to which solution of soda and alum are sometimes added. After the cotton thus prepared has been completely washed, it is well maddered, then dipped in a weak solution of sulphat of copper, and lastly, in soap suds.

The processes by which dark colours are given to printed linens are very simple; the parts which have been impregnated with a solution of iron, acquire in the maddering, a violet colour approaching more or less to black; those which have been impregnated with the solution of iron and the acetite of alumine, take brown and puce colours.

When a stuff which has received a colour, is dipped in a black bath more or less diluted, the effect produced is simple; it is a shade of black more or less deep, which is united to the first colour.

This is not the case when the coloured stuff is dipped in a solution of iron; for then, the colouring particles which were attached to the stuff, act upon the sulphat of iron, take up a part of its oxyd, and combine with it and the stuff: the colour which results from this union is more or less deep, not according to the colour which is proper to the colouring particles, but chiefly, according to the action which they exert on the metallic oxyd, agreeably to the principles laid down in the first part; thus the brasil and logwood which enter into the composition of a colour, will produce a much more remarkable effect in the browning, than madder or cochineal; galls and sumach will produce a still more considerable one, though they only affected the original colour by the production of a fawn-coloured shade.

If a black bath be prepared, or a black dye produced, either in the mordant, or in the dye bath, the ingredients which are mixed with the colouring substances will influence the result

of the operation by the action they exert on the black particles; thus, alum, solution of tin, and solution of indigo, will weaken the effect which the black particles would have produced: all the acids will act in the same manner, except the acetous, and perhaps some other vegetable acids which have not the property of dissolving the black particles: it would seem that nitre is capable of dissolving them, as it renders the colours in which it is employed, lighter.

As the best colours which can be given to thread and cotton are obtained from madder, the different means mentioned in treating of madder, for rendering this dye more durable must be attended to, and the colour may be rendered darker by different black baths.

For some hazels and snuff colours, a browning with foot is given, after the welding and madder bath, to which galls and fustic have been added; foot is sometimes mixed with this bath, and a browning is also given with a solution of sulphat of iron; walnut-peels are sometimes substituted for solutions of iron in browning colours. They have a great advantage for the wools intended for tapestry, for the colour does not grow yellow by long exposure to the air, as happens in the browning produced by iron, but

but remains a very long time without change; it has indeed a dull hue, which is proper for shades, and to represent the colour of the flesh of old figures, but which would produce only dull and heavy colours in stuffs; the goodness and cheapness of this colour however, ought to render its use more extensive for grave colours, which are sometimes fashionable, at least in common stuffs.

An infinity of shades are made by this browning at the Gobélins: to produce an assortment of these, a boiling with tartar and alum of different degrees of strength according to the shades required, is given to the woollen yarn, which is then successively dyed red, yellow, or some other colour, recurring to the bath from which we wish to obtain a greater effect. When the colour is found to be of the proper shade, it is left for a longer or shorter time, in a bath of walnut-peels of a degree of strength adjusted to the end proposed. This browning is also employed for silk, but then, the bath must be scarcely warm, that the inequalities to which it is very liable may be avoided.

DESCRIPTION

OF THE

TRANSLATOR'S APPARATUS

For the Distillation of ACIDS and
other SUBSTANCES.

The Plate being upon the Scale of about an Inch to a Foot.

A IS the retort, the neck of which is ground into and passed through the thick stopper B, represented below separately at b, with its ground stopper a, which may be put in when the neck of the retort is withdrawn. The external part of the stopper B is accurately ground into the wide neck of the receiver C, the narrow neck of which is ground into the wide neck of the receiver D, the narrow neck of which is ground into that of the receiver E; in the receiver D there is also another aperture in its superior part, into which the tube H open at both ends, is fitted by grinding, so that its lower

lower extremity may reach to the lowermost part of the receiver, and consequently be immersed in any fluid that may be contained in it. Into the small neck of the receiver D, there is also ground a crooked tube I, forming a little more than one fourth of a circle, open at both ends, and extending to very near the lower part of the receiver E, the small neck of which receives a similar crooked tube K; and is received into the wider neck of F, which receives the tube L in like manner, and is received into G, the narrow neck of which also receives a crooked tube M N, open at both ends and bent as represented in the plate; so as to convey any aerial fluid into the small inverted cup, where it is collected and directed to pass by the hole represented in the plate, into one of the four inverted bottles placed above it, by means of the moveable frame P; which having four notches to retain the bottles in an upright inverted position, is movable on the centre support kept steady by means of a heavy leaden foot, in the centre of a flat pan of water, which covers the mouths of the bottles. The water which issues from the bottles when the air is introduced, and which would make the pan overflow, is directed by a notch in its lip, and the

pipe Q, into the bucket R placed under the frame, which raised upon four legs serves to support the whole apparatus, the different parts of which being successively applied to each other, beginning with the receiver C, are kept in a fixed position by slips of wood hollowed out so as to fit the curvature of the receivers, as represented below detached at S s. Heat is applied to the matter contained in the retort A, by means of the lamp placed below it, which is upon Mr. Argand's principle, and a very useful acquisition to the laboratory: of this 1 represents the chimney which is most conveniently made of thin metal, as brass, copper, or common tinned iron plate, which being opaque, the flame of the lamp within is not seen. Metallic chimneys are preferred, because they are not liable to be broken, and because it is the heat and not the light which is here wanted; 2 is the bent wire serving to elevate or depress the wick; 3 the reservoir for the oil; 4 the support of this, with a small cup to receive the oil which may drop from within the wick without being consumed; 5 a pin with its screw for fixing the lamp at any distance from the retort.

Of the Use and Advantages of the above Apparatus.

IN the annexed plate, the apparatus is represented as employed in the distillation of a substance, the vapours of which condense with difficulty, such as the oxygenated marine acid. Let it be supposed then that the common salt, and calx or oxyd of manganese have been put into the retort : the vitriolic acid is next introduced by means of a retort funnel ; and this being withdrawn, the neck of the retort is immediately introduced into the stopper B, the other parts of the apparatus being previously disposed as in the plate. The lamp is then brought under the retort, but at a moderate distance, that the retort may not be cracked by the too sudden application of the heat, nor the vapours be driven over too rapidly into the receivers. As soon as the heat is applied the salt is rendered fluid by the vitriolic acid, and the marine acid getting pure air from the manganese, begins to pass over into the receiver C, in the state of oxygenated marine acid : into this, no water has been put, in order that the vapours of the common marine acid may here be condensed separately.

The

The vapours of the oxygenated acid meeting with no water here, pass into the receiver D, where a small quantity is put, by which a part is condensed, but another part passes over into the receiver E; but for this purpose it must go through the tube I to the bottom of the water which is placed in that receiver, and that part which is not condensed there, must rise up through it in bubbles as represented in the plate: these, circulating in the receiver E if not condensed, will pass through K, and the water in F into its upper part, and in like manner to L, where if not condensed, they will be conveyed through the tube M N by means of the cup into the bottles, each of which will in its turn be brought over the little cup, while the others being filled with the air, will be removed and replaced by fresh ones filled with water, without any loss of the air, or interruption to the process: at the same time all inconvenience from the overflowing of the water will be obviated by the tube Q. To those who have been accustomed to employ the different kinds of apparatus hitherto in use for the distillation of the acids, particularly the marine acid, I conceive the advantages of this will be sufficiently evident; but to those who have had little or no experience
in

in this respect, it may not be improper to mention a few particulars. First then, in this apparatus, there is no necessity for having the retort tubulated, for the neck of the retort being ground into the stopper B, is as easily introduced into that while fitted into the first receiver, as the stopper would be into the superior opening in the retort. This joint is more likely also to be close, as the neck of the retort is expanded when heat is applied, rather sooner than the orifice into which it is inserted, because it is to the retort that the heat is more immediately applied; whereas in the tubulated retort, the reverse of this takes place, the opening being in the retort itself, and the stopper being foreign, and heated only through the medium of the retort. The neck of the retort is ground into the piece B, and not into the receiver C, because the retorts being much more frequently broken, the neck of this receiver would soon be worn out by the grinding; besides in this way, when the retort is broken, the receiver being large, is not so conveniently ground as the piece B, and it is also in this way constantly preserved clean, and never dirtied by the sand or other substances used in grinding. In the receiver D, there is the tube H, which being open at both ends,

ends, but having its lower extremity immersed in the water, allows a passage for the atmospheric air downwards, when the vapour is suddenly condensed by the diminution of heat; but prevents the escape of the vapour upwards: for when the vapour presses on the surface of the fluid in D with an increased force, a column of the fluid there, is raised in the tube which is somewhat more than equal in height to the perpendicular altitude of the immersed parts of all the other tubes taken together.

This tube, which has been called a tube of safety, is an useful addition to the apparatus, and is said to be the invention of a Mr. Welter. In Mr. Lavoisier's apparatus there is one to each of the bottles, but this does not appear to me to be necessary, as the absorption is never rapid except in the retort, and the first, or at most, the two first receivers; and in the apparatus here represented, there is no crooked tube between the first and second receiver, which might convey the liquor of the second into the first receiver. When only one tube is employed, the quantity of fluid at first put into D should be but small, as a part of that from E may possibly pass over into D.

This

This apparatus has many advantages over any that I have seen. Its joints are ground instead of being luted, and I always find that the purity of the product is injured by lute, either during the operation, or when the product is removed: as all the joints are concentric, they are easily ground; the joints are very strong: many of the joints cover others, so that some of them may be bad without much injury to the apparatus; any of the joints of the tubes I, K, L, for instance, may be bad, with very little inconvenience, as any person may be convinced by leaving any of the tubes a little loose. When a moderate degree of heat only is required, we have no occasion for a furnace, a lamp answering the purpose of one completely, and indeed having several advantages over it.

For first, we have the heat more immediately in our power, as we can raise, or lower, or remove it altogether, by merely changing the elevation of the lamp, and we have an easy rule for this management of the heat, in the velocity with which the air bubbles pass through the fluid in the different receivers, and in the height of the fluid in the tube H. It may not be improper to remark that when the heat is suddenly removed, if the diameter of the
tube

tube H be small, it will be proper to blow a little air through it, lest the water should get into the receiver D from E.

Secondly, it enables us to estimate the weight of the products at any time during an operation: the weight of the retort and ingredients having been previously noted, we can at any time during the process that we judge proper, remove the retort, stopping the hole from which it was withdrawn with the small stopper a, weigh it, and return it, (this need not take up more than half a minute) and in the difference of the weights, we have the weight of the product.

In every case where the lamp is suddenly withdrawn while the retort is hot, and always when an operation is finished, it will be proper to surround the retort with a quantity of dry tow, flannel, or any other rare substance which transmits heat very slowly, that it may not be cracked by the sudden change of temperature: another circumstance which should be attended to, in order to prevent the breaking of the retort, is, that its neck should be placed with such a degree of inclination, as to allow the drops formed in it by the condensed stream, to run freely into the receiver; as if they should fall back, when the residuum in the
retort

retort is growing dry, they will certainly crack the hot glass. In the apparatus which the annexed plate represents, this end is accomplished by inclining the support of the whole apparatus as there represented; but it may be done in a way which I have adopted since that drawing was made, and which seems preferable in some respects, particularly in this, that it admits of the support being horizontal, which enables us to put more water into the receivers. The retort is made to incline by the hole in the piece B, which receives its neck passing obliquely through it, so as to make the end of the retort within the receiver to dip considerably, while its own external part ground into the receiver C, is in a horizontal position: it is perhaps needless to add, that by varying the shape of the receivers, their effect may in some measure be varied; thus by making them of an elliptical shape instead of globular, if the short axis of the ellipses be placed horizontally, we may proportionally increase the pressure of the uncondensed vapour on the surface of the fluid they contain, whereas, if the long one be placed in that direction, we may increase the surface of the fluid exposed to its action. It seems also unnecessary to observe, that if the use of a furnace be preferred

preferred to that of the lamp, all the other advantages of the apparatus remain the same; and if the retort be of a large size, that a furnace must necessarily be employed, as the neck of the retort might not be able to support the weight of the matter it contained.

V O C A B U L A R Y.

A

ACETITES, salts formed by the union of the acetous acid, or distilled vinegar, with different bases.

Acetite of Alum, acetated clay.

— *Ammoniacal*, Mindererus's spirit.

— *of Copper*, crystals of venus, or distilled verdegris.

— *of Lead*, sugar of lead.

— *of Lime*, acetous salt of lime.

Acid Acetous, distilled vinegar.

— *Carbonic*, fixed air, aerial acid, mephitic acid.

— *Citric*, lemon juice.

— *Gallic*, gallic acid, astringent principle.

— *Muriatic*, marine acid, spirit of salt.

— — *oxygenated*, dephlogisticated marine acid.

— *Nitric*, dephlogisticated nitrous acid, white nitrous acid.

— *Nitrous*, phlogisticated nitrous acid, smoking spirit of nitre.

— *Nitro-muriatic*, aqua regia.

— *Oxalic*, acid of sugar, of sorrel, saccharine acid.

— *Phosphoric*, acid of phosphorus.

— *Prussic*, colouring matter of prussian blue.

— *Sulphureous*, volatile sulphureous acid, volatile vitriolic acid, phlogisticated vitriolic acid.

— *Sulphuric*, vitriolic acid, oil of vitriol.

— *Tartareous*, acid of tartar.

Alcohol, spirit of wine.

B b

Alumins,

Alumine, earth of alum, pure argillaceous earth, pure clay.

Ammoniac, caustic volatile alkali, volatile spirit of sal ammoniac.

B

Barytes, basis of heavy spar.

C

Caloric, matter of heat.

Carbone, pure charcoal.

Carbonats, salts formed by the union of the carbonic acid with different bases.

Carbonat of Alumine, aërated argil.

— *of Ammoniac*, concrete volatile alkali, mild volatile alkali.

— *cf Lime*, chalk, aërated calcareous earth.

— *of Magnesia*, magnesia alba of the shops, aërated magnesia, muriatic earth.

— *of Pot-ash*, salt of tartar, mild vegetable fixed alkali, salt of wormwood, aërated vegetable fixed alkali, salt of tartar, mephitic tartar.

— *of Soda*, natrum or natron, marine or mineral alkali, crystals of soda, aërated soda, mild mineral alkali.

E

Ether Sulphuric, vitriolic ether.

G

Gas, gas, elastic fluid, aëriiform fluid.

— *Azotic*, phlogisticated air, phlogisticated gas.

— *Carbonic Acid*, fixed air of Dr. Black, mephitic gas.

— *Hydrogen*, inflammable air, inflammable gas.

— *Muriatic Acid*, marine acid air or gas of Dr. Priestley.

— *Oxygen*, vital air, pure air, dephlogisticated air of Dr. Priestley.

Muriats,

M

Muriats, salts formed by the union of the muriatic acid with different bases.

Muriat of Alumine, marine alum, muriated clay.

— *of Ammoniac*, sal ammoniac.

— *of Mercury corrosive*, corrosive sublimate.

— *of Pot-ash*, Sylvius's febrifuge salt, regenerated sea-salt.

— *of Soda*, sea-salt, common salt.

N

Nitrats, salts formed by the union of the nitric acid with different bases.

Nitrat of Alumine, nitrous alum, argillaceous nitre.

— *of Ammoniac*, nitrous sal ammoniac, ammoniacal nitre.

O

Oxalats, salts formed by the combination of the oxalic acid with different bases.

Oxalat Acidulous of Pot-ash, common salt of sorrel.

Oxyd, calx.

— *of Iron*, yellow, ochre.

Oxyds of Lead, calces of lead.

Oxyd of Lead, white, by the Acetous Acid, white lead.

— *of Lead*, semi vitreous, litharge.

Oxygen, basis of vital air, acidifying principle.

P

Pot-ash, caustic vegetable fixed alkali.

Prussiats, salts formed by the union of the prussic acid, or colouring matter of prussian blue, with different bases.

Prussiat of Pot-ash, saturated ferruginous, prussian alkali.

S

Soda, caustic soda, marine alkali, mineral alkali.

Sulphats, salts formed by the combination of the sulphuric acid with different bases.

Sulphat of Alumine, alum, vitriolated clay.

— *of Copper*, roman vitriol, blue stone, vitriolated copper.

— *of Iron*, green copperas, salt of steel.

— *of Lead*, vitriol of lead.

— *of Lime*, vitriolated lime, selenite, gypsum, plaster of Paris.

— *of Magnesia*, vitriolated magnesia, epfom salt.

— *of Pot-ash*, vitriolated vegetable alkali, vitriolated tartar, vitriol of pot-ash.

Sulphurets Alkaline, alkaline livers of sulphur, alkaline hepars.

Sulphuret of Antimony, crude antimony.

— *of Pot-ash*, liver of sulphur, having for basis the vegetable alkali.

T

Tartrites, salts formed by the combination of the tartaric acid with different bases.

Tartrite Acidulous of Pot-ash, tartar, cream of tartar, crystals of tartar.

— *of Pot-ash*, soluble tartar.

I N D E X.

The letter B refers to the Second Volume.

* * When B is placed before the first number referring to a page in any article, it is to be understood that the second volume is referred to through the whole of that article.

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E R R A T A.

Page 85, line 11, *for* larger, *read* longer.
— 231, — 3, *for* aucupatorius, *read* aucupatoria.
— 353, — 5, *for* are, *read* is.

